TARLAN: A Simulation Game to Improve Social Problem-Solving Skill of ADHD Children

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To my darling son, **Rastin**

and

to the beloved Iranian children

Abstract

Traditional classrooms in which children are expected to sit down quietly and listen to the teacher are not attractive to students in the era of technology. Therefore, researchers have started to study the possibilities of applying modern approaches to educational contexts. The interactive nature and the attractive virtual environment of computer games have made them a high-potential context for learning purposes. Sitting in a classroom is challenging for students with Attention Deficit Hyperactivity Disorder (ADHD)because of their inattentiveness, impulsivity, and hyperactivity, so that they distract easily.However, researchers have discovered that children with ADHD are not distracted when playing computer games. Therefore, computer games can be beneficial learning contexts that can attract ADHD children's attention in order to teach them.

So far, a large number of studies have been conducted to help ADHD children. Some researchers have worked on cognitive-training approaches to improve skills such as eye gaze, emotion recognition, and working memory enhancement of ADHD children. In addition to the core deficits associated with ADHD, children with ADHDalso face difficulties in social situations, because they are not equipped with the required social skills. Therefore, they face many problems in society that they cannot solve. Consequently, they face peer rejection or social isolation and other mental health problems.

Social problem solving is a step-by-step process. For ADHD children, learning the different steps of social problem solving is difficult because they are inattentive. Moreover, acting upon the steps is also hard for ADHD children because they are impulsive.

We developed a simulation game, named TARLAN, wherein different steps of solving a social problemare taught to ADHD children. We designed and developed real life scenarios in which children can practise, in order to enable them to apply what they have learnt from the game to real-life situations.TARLAN was designed in three phases, from the elementary level to more advanced levels in order to help the ADHD child gradually become an independent problem solver in society. That happens by building strong

scaffolding around the child’s learning on the elementary level and remove it in the more advanced levels. This scaffolding/levelling within games has positive learning outcomes. Forty children with ADHD aged 8-12 were randomly allocated to two interventions, a computer-based intervention in which children worked with TARLAN and another intervention which was a standard psychological intervention. We also had a control group in which 20 children without ADHD also worked with TARLAN.

The effectiveness of our game in improving social skills as well as problem behaviour of ADHD children was evaluated using the Social Skills Improvement System (SSIS), which is a standard psychologicalmeasure. The results of the SSIS showed that TARLANimproves children’s social acquisition and problem behaviour significantly more than a more expensive standard intervention led by a psychologist (role playing).Moreover, after analysingdata collected during the study,we found out that TARLANimproved children’s performance: the ADHD children reached the same performance level as children without ADHD after working with the game.

These results open up the possibility of using games as helpful tools in teaching important life-changing subjects that are hard for ADHD children to learn from traditional approaches. Therefore, the educational life of ADHD children can be changedfrom a challenging experience into a rewarding and attractive experience and time and money can be saved.

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1. Introduction

There has arisen an increasing interest in using active learning approaches in educational contexts. That is mainly due to the fact thatthese approaches can positively impact learning. In the current digital generation, the role of video games is growing. Therefore, a compelling need for a deep knowledge of their real effect on learning is perceived, especially by teachers as this knowledge enables them to choose the right tool to be used in classrooms (Kaufman & Sauve 2010).

Teaching young children is simultaneously important and challenging. A child's mind is dynamic and creative and has great capability of learning. Having this in mind, we have targeted children learners as case study in this research. In order for the child to learn, his/her attention needs to be focused on the teaching material. It is hard for children with learning disorders to pay enough attention to learning. Developers of educational software have to consider the fact that designing software packages for children differs from designing ones for adults. Moreover, children's age and their special needs play big roles in this regard.

1.1 Learning with Games

According to Merriam-Webster dictionary learning is "the activity or process of gaining knowledge or skill by studying, practicing, being taught, or experiencing something. Application of computer games in educational contexts has been studied for more than two decades (O'Neil 2007; Bonk & Dennen 2005). Although there are some strong negative perspectives about the use of games for educational purposes (Sandford et al. 2006), the effectiveness of educational games has been depicted in many studies (Habgood et al. 2005; Gee 2003; Sanchez et al. 2010; Baghaei et al. 2012; Annetta 2010). However, the effectiveness of games on learning depends on the quality of the game design. Designers of educational games have different views about the objective of the games. Some designers emphasise the importance of motivating and engaging the learner (Zimmerman 2013);

while others are driven by traditional instructional approaches and believe in including meaningful activities in the game (VanEck 2006). However, an intersection of these two approaches has been found as an effective way in designing games in educational contexts by many scholars (Cannon-Bowers & Bowers 2010; Shelton & Wiley 2007). According to this latter approach, in order to make a successful educational game, designers have to balance the instructional goals with the motivational goals. Sanchez and colleagues (2010) introduced a framework for organizing gaming features for the purpose of learning (Figure 1).

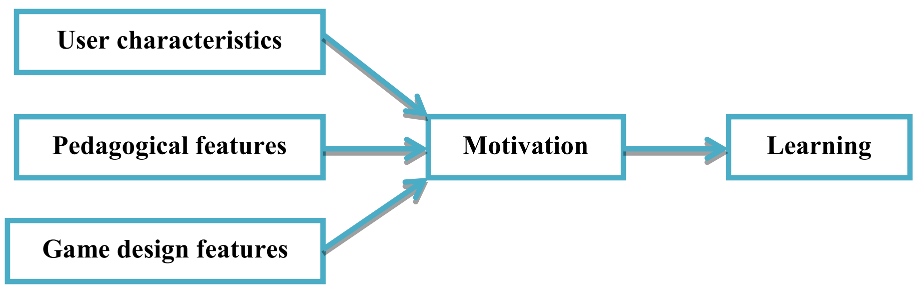

Figure 1: Framework for organizing gaming features and learning (Sanchez et al. 2010)

As seen in Figure 1, a well-designed educational game has to motivate the users, which in return affects learning outcomes. Sanchez and colleagues (2010) argue that in order to motivate the learner, designers have to take three features into account when designing educational games: user characteristics, pedagogical features, and game design features. Every individual has their backgrounds and that accordingly causes them to like or dislike the environment of the game which has positive or negative impacts on their motivation. Therefore, considering preferences and expectations of the targeted users can be useful in designing motivating games. Pedagogical features have been provided for different categories of learners in form of heuristics in the fields of education, psychology, and training. Educational game designers can obtain pedagogical features of their target users by generalizing these heuristics. Finally, designers have to apply the theories of plays, entertainment, challenge and fun to keep the environment attractive for the learner (Sanchez et al. 2010). Consequently, according to Shelton & Wiley (2007), game designers have to plan the instructional objectives of the game in order to retain the main goal of educational games which is to facilitate flexible delivery of complex information while maintaining high levels of motivation.

1.2 Social skills

Gresham & Elliott (2008) define social skills as "learned behaviours that promote positive interactions while simultaneously discouraging negative interactions when applied to appropriate social situations". Moreover, Spence (2003) believes social skills are the ability of performing those behaviours that are critical in enabling a person to achieve social competence. However, she has defined social competence as the ability to obtain successful outcomes from interactions with others. Children normally learn social skills by watching their parents, copying the schoolmates' behaviour or learning from feedback. Children with ADHD (Attention Deficit Hyperactivity Disorder) simply miss these lessons as they have learning problems, emotional problems, conduct disorders and general psychiatric problems (Spence 2003). ADHD people may face difficulties in social situations as they lack the ability of analysing the social situation, and fail to recognize the different perspectives that an ordinary person may obtain from a social situation. Therefore, they cannot take appropriate action in these specific situations(Goldsworthy et al. 2000) and they cannot also realize the right and wrong issues easily, thus, they repeat ineffective behaviours. They are bossy, disruptive and easily frustrated in group plays, hence, a great number of them encounter difficulties in their everyday relationships (Spence, 2003) and also in academic and behavioural needs (Goldsworthy et al. 2000). According to the National Resource Centre on ADHD, 50% to 60% of the ADHD children cannot make healthy peer relationships. The main drawback of not learning social skills in ADHD children is peer rejection (Modesto-Lowe et al. 2008), which can result in low self-esteem, depression and anxiety. Also, if they are not well-equipped with the required skills to overcome their childhood problems, they may struggle with the same problems in their adulthood. Moreover, by learning social skills, they can improve their peer relations, academic progress, irresponsibleness and self-esteem (Brown & Perrin 2007; Hupp et al. 2009).

Knowing how to solve problems in social contexts is equally important as in educational contexts. When a child has some cognitive deficits, solving everyday social problems like having an argument with a friend or not having been invited for a party can be as difficult as solving a challenging math problem. That is because people with cognitive deficits like ADHD cannot apply methodical problem-solving skills naturally. Therefore, their actions are mainly based on trial and error and they repeat the same errors. There is a need to teach them problem-solving strategies from early ages to attempt to prevent longstanding challenges in this area.

Social skills are one of the most important skills as they affect children's progress and success in their everyday life (Spence 2003; Gresham & Elliott 2008). Children start experiencing their independent social life in early childhood. Hence, they need to be equipped with the necessary social skills to have fulfilling lives. Gresham & Elliott (2008) argue that students who are socially skilled pay more attention to the speakers, cooperate better in group works, ask for help when they need and behave more responsibly. They also believe that social skills persist without intervention. Problem solving is one of the most crucial skills that help children survive and deal with their everyday social problems with a strong attitude without being hurt.

When children are equipped well with different skills since early ages, they can start to apply their knowledge through their lives for longer. It may also help them to gain more control over their lives and suffer less.

1.3 Skill Competency in ADHD Children

Gaining social skills is difficult for children with special needs such as those diagnosed with ADHD or Aspergers syndrome. ADHD is a developmental disorder composed of different difficulties with unknown aetiology (Parsons et al. 2007). Inattention, hyperactivity and impulsivity are three symptoms of ADHD (Excoffier 2006; Cho et al. 2002). With a more detailed look at ADHD behaviours, (Parsons et al. 2007)extra symptoms like distractibility and impaired cognitive flexibility are also added. Cognitive flexibility is the ability to change one's behaviour according to the situation.

Children with social deficits face emotional and behavioural problems both at the current age or in the future (Spence 2003). Social problem-solving skill is a formulated step-by-step process; thus, it can be computerized with the aid of software engineering to make it available for teachers and caregivers more conveniently. The main aim of this research is to develop a simulation game for ADHD children aged 8 to 12, in order to teach them social problem-solving skills. The goal of the proposed software is to help ADHD children to become independent social-problem solvers by applying animated scenarios. Teachers need to spend a large amount of time to teach new concepts to ADHD children. Also, they need to repeat learning materials over and over again throughout the learning process. Consequently, we designed and developed a simulation game as a tool that can be used by ADHD children in order to learn social problem-solving skills in an attractive environment.

1.4 Research Structure

This research began with a comprehensive literature review in different domains including psychology, computer science, education, and neurobiology. Our main focus was on children with ADHD, educational computer games, and the brain's functionality and how it is different in ADHD people. We needed to know what ADHD children's special needs are and how they can be improved by the aid of computer science. After conducting the literature review, we started to design the system followed by designing the experiment. This stage was quite challenging as we needed to discuss every sentence and scenario with a psychologist in order to develop a well-designed end product for our specific target group. Software implementation started in parallel to the system design by trying different software applications to find the most appropriate one. Finally AdobeFlash 5 was chosen as our development tool. Mention should be made that we have submitted and presented two conference papers and a conference poster to the NZCSRSC2012 conference, ITS2012 conference and NZ-OZWIT conference respectively which have all been derived from this research (the papers are provided in Appendix E). We had an interview about our findings on the TV show, Voice Of America (VOA/ Persian branch) in August 2014[1].

1.5 **Thesis Outline**

The thesis report is divided into six chapters. In *Chapter two(*Background), we provide a comprehensive review of the ADHD disorder including the definition of ADHD, different types, symptoms, intervention and diagnosing approaches, causes of the disorder and so on. After that we argue the need to equip children with social skills especially social problem-solving skills and the reason ADHD children lack them. Then we study common approaches in teaching social problem-solving skills to normal children and justify how they should be modified to be applicable to ADHD children. Furthermore, we look at the multimedia learning in general followed by the description of the cognitive theory of multimedia learning and the seven principles in designing effective multimedia educational environments. Related works done so far to help ADHD children with the aid of computer science technologies have been outlined. Finally, we discuss games, simulation and simulation games to get a clear idea in what category our system should be situated.

Chapter three(System Design and Development) is a description on what framework we used in designing the system, what social skills and social contexts we chose to include in the system and why. We also discussed about how the animated scenarios were designed, and how the user interface was designed and developed for different phases of the system.

*Chapter four(Experiment Design*discusses the system implementation for a typical scenario. This chapter outlines how we designed the experiment, how the pilot study was conducted, and how the participants were recruited and allocated to the different groups in the experiment. Also the assessment process has been explained at the end of this chapter.

Chapter five(Results) presents the results of the SSIS test as an external measure as well as the results from analysing the interaction data extracted from the captured screens while participants worked with the system. More results from analysing patterns of mouse

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[1]http://ir.voanews.com/media/video/streets_of_life/2470319.html?z=1571&zp=1

movements as well as the nature of the designed problems have been outlined in this chapter. Finally, *Chapter six(Discussion)* outlines the conclusion and presents future directions for research in this area.

2. **Background**

A knowledgeable teacher knows that the learner's attention is as important as the quality of teaching(McArthur 2002). Traditional instructional approaches that aim to transfer the teacher's knowledge into the student's brain do not work effectively for ADHD children (Reeve 1990). Such approaches are based on repeating the lessons several times and expecting the learner to memorize as much knowledge as they can and not necessarily on applying the acquired knowledge practically in real life. On the other hand, good teachers encourage learners to apply what they learn in real life. The main problem with ADHD children is their inability to sustain attention for more than a few minutes during the learning process. Therefore, teachers have to take advantage of any opportunities to take hold of the attention as well as repeating learning materials to make sure that the ADHD child has learnt the lesson well. Some studies such as Goldsworthy et al. (2000) argued that regardless of their inability in sustaining attention, ADHD children can concentrate well when doing some specific tasks such as playing computer games. They found the reason they can concentrate under such circumstances is due to the attractiveness of the activity which is engaging enough to keep the ADHD's brain awake.

One type of skill that ADHD children typically lack is social skills(Wilkes et al. 2011; Van der Oord et al. 2005; Goldsworthy et al. 2000; de Boo & Prins 2007). Teaching social skills to ADHD children can be quite challenging. Well-resourced parents know that making a safe and enjoyable life for their children only is not enough to make a happy future for them. They must also equip their children with the required skills in order to help them socialize with others independently. Teaching these skills to children with special needs demands considerable amount of time and patience. Sometimes the situation is out of the parent's control. Therefore, depending on the parent's awareness, knowledge, time and budget, they act in different ways. Some seek extra help from professionals, while others think they can solve the problem themselves. Moreover, some disorders have physical signs so that people can distinguish the affected person from the normal person easily. However, in some disorders we cannot find much difference in the person's appearance compared to a normal person. In such cases some parents may not realize that there is some dysfunction in their child's body. As a result, they blame themselves for not being good parents and not having trained their child well. ADHD is one of these disorders the problems of which can be diagnosed using interviews and questionnaires by the psychologists.

In this research we have integrated different methods in order to tailor a specific approach for teaching social problem-solving skills to children as well as applying their knowledge in real life situations.

2.1 **What is ADHD?**

Sir Alexander Crichton first described restlessness and problems with attentionin 1798 (Palmer & Finger 2001). Although he did not define these problems as ADHD, the features are what we know as ADHD at present. He wrote a full chapter about this disorder in his book "An Inquiry into the Nature and Origin of Mental Derangement" (Palmer & Finger 2001). After Crichton's work, researchers started to study this mental state with people of different ages with a remarkable rise of interest in this mental health condition since 1994 (Wilson 2004).

ADHD people have major problems in their relationships with people around them, which cancontinue into adulthood (Cho et al. 2002). This disorder has been identified as the most common childhood behaviour disorder affecting 8% to 10% of children, which can continue into adolescence in approximately 80% of cases (Slate et al. 1998; Anton et al. 2009). Both assessment and therapy are needed for this disorder ideally before the age of seven, as untreated ADHD can have a significant impact on the child, their immediate family, and the whole society (Anton et al. 2009). Moreover, adults with ADHD are at greater risk of dangerous driving (Thompson et al. 2007; Anton et al. 2009) or committing crimes (Fletcher & Wolfe 2008) as compared with adults without ADHD. Also, as ADHD children are unable to maintain focus, they cannot finish a task; therefore they change jobs quite often (Thompson et al. 2007). Untreated children with ADHD can have problems with higher education. In addition, their difficulties in personal relationships, social skills, time management and self-organization lead to social isolation, which may result in depression or other mental problems (Harpin 2005). Therefore, having a way of helping ADHD children to control their disorder provides them a well-organized foundation for their future.

2.1.1 ADHD Symptoms

There are three main symptoms for ADHD: inattention, hyperactivity and impulsivity, each one with specific behaviours associated to it (Blythe & Laura 2006; Wang & Reid 2011; Schweitzer et al. 2001; Mulder 2010; Rucklidge et al. 2011; Newman et al. 1997; Cho et al. 2002; Reeve 1990; Steiner et al. 2011a).

Inattentive children are not able to focus on a task and they become easily distracted (Cho et al. 2002). Sitting in a classroom is the biggest challenge for them as there are a lot of distractions in the classroom (Schweitzer et al. 2001). They also seem not to listen when they are spoken to (Palmer & Finger 2001).

On the other hand, hyperactive children arevery energetic so that they cannot stay still in their place(Steiner et al. 2011a). Other behaviours include tendency to talk with a loud voice (Reeve 1990), not being able to sit at dinner table (Schweitzer et al. 2001), having trouble waiting for their turn in games or waiting in queues (Reeve 1990), misplacing things, and getting late for their appointments or classes.

We normally think before taking an actionin order to be safe in risky situations. Conversely, children with impulsivity do not think before doing something. Instead they react upon the first thing that comes to their mind (Goldsworthy et al. 2000). Being impatient and making inappropriate comments and not being able to control emotions are the results of impulsivity. In addition, impulsive children cannot justify their behaviours.

There are many challenges to studying ADHD. For example defining a clear borderline between normal level of inattention, hyperactivity and impulsivity and problematic level of these symptoms, has been of a concern for the researchers for several years (Excoffier 2006). Resolving this ambiguity is important in designing appropriate interventions for

ADHD people in both clinical and academic contexts. Sometimes ADHD can co-occur with other psychiatric disorders. When two disorders co-occur we call them comorbid (Harpin 2005). Furthermore, neuropsychological profiles of individuals with ADHD people showthat aetiology of the ADHD symptoms can vary from one child to another (Purper-Ouakil et al. 2011).

2.1.2 WHAT ADHD IS NOT?

Many symptoms of ADHD are similar to symptoms of other common disabilities such as Learning Disability (LD) or Sensory Processing Disorder (SPD). As a result, sometimes ADHD is misdiagnosed as other disabilities. Although differentiating one disability from another may be difficult, there are some cardinal features to each one that may help in diagnosing them.

ADHD and learning disabilities have some common symptoms such as poor attention to the teacher or negative behaviours. However, there are some major differences between the two disorders. Each country has its own definition of learning disability (Westwood 2008), but ADHD is almost known consistently world-wide. Furthermore, people with learning disabilities can be recognized mainly by their problems in literacy and numeracy (Westwood 2008), while the main problems with ADHD people are behavioural and social problems.

On the other hand, Sensory Processing Disorder (SPD) is a condition that a person cannot give an appropriate response to the information s/he receives from the environment. SPD and ADHD have some common symptoms such as being fidgety or hyperactive. However, according to Kranowitz (2005), there are two cardinal features for SPD that help in differentiating the two disorders: 1) a child's unusual responses to touching and being touched or 2) to moving and being moved. She has also brought the results of other researchers into account when mention in another difference between SPD and ADHD, that is, the way they respond to the unexpected sensations, such as light touches, loud noises, flickering lights, strong smells and being tilted backward in a chair. Children with ADHD are alert to these novel sensations and then, like most people, get used to them (life goes on); whereas children with SPD show two types of reactions. Some of them may not alert to these sensations (life does not affect them much), while others may be continually on alert and do not habituate to them at all (life affects them too much) (Kranowitz 2005).

2.1.3 THE CAUSE OF ADHD

The exact cause of ADHD is not known. Research has revealed the role of both genetic (Arnsten 2009; Excoffier 2006; Furman 2008) and non-genetic (Joseph 2000; Froehlich et al. 2011) risk factors in originating ADHD. For example according to Froehlich et al. (2011) environmental factors such as prenatalsubstance exposures, heavy metal and chemical exposures,nutritional factors, and lifestyle/psychosocialfactors affect ADHD.

In order to have a clear view on the ADHD brain, we put a brief description of the human brain. Our brain consists of different sub-regions, each responsible for certain tasks (Figure 2). On the other hand,in the ADHD brain there is a functional networkfor each functional task that makes a pathway to connect the separate sub-regions together in order to perform each specific task Figure 3(Purper-Ouakil et al. 2011).

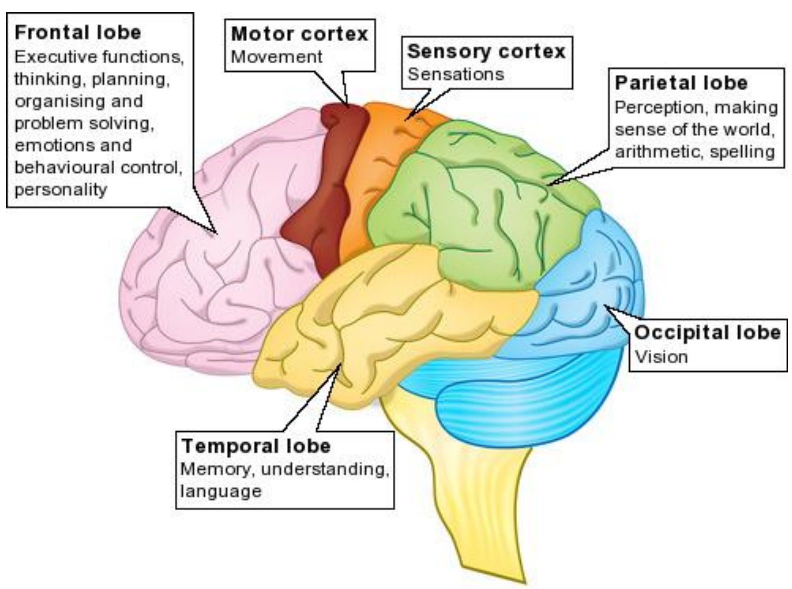


Figure 2: Different parts of the human brain (From: http://deliamireya.blogspot.co.nz)

The frontal part of the brain is responsible for executive functions that play a vital role in performing functional tasks (Blythe & Laura 2006). Executive functions include problem solving, attention, reasoning, planning and so on (Aman et al. 1998). ADHD has a neurological basis that causes the frontal cortex not to work properly (Alhambra et al. 1995; Willcutt et al. 2005; Graham 2013). All of the pathways pass the frontal cortex either as a source or a destination or bothFigure 3. That means the pathways do not conduct their associate tasks correctly.

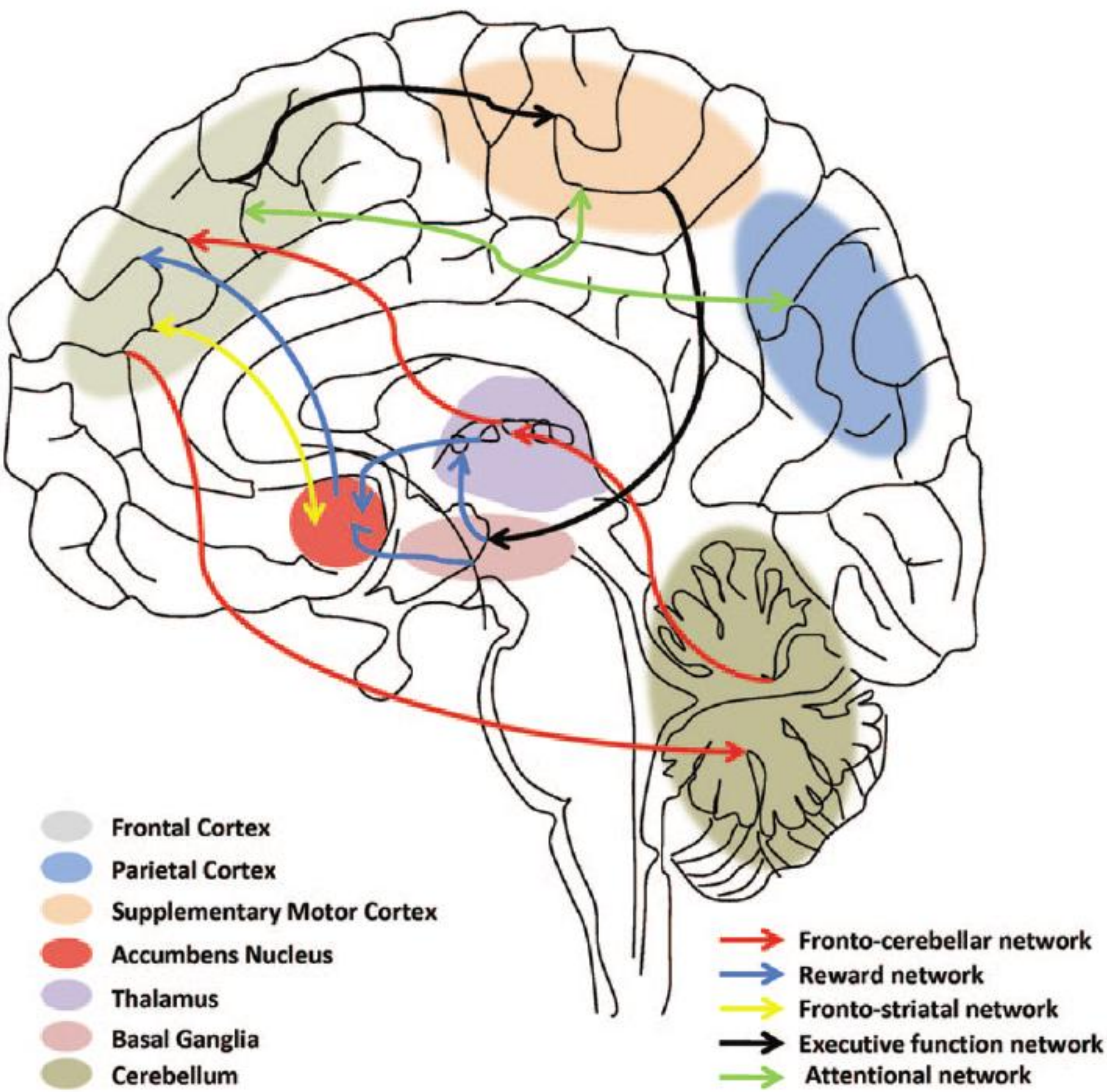


Figure 3: The functional networks of the ADHD brain (Purper-Ouakil et al. 2011)

2.1.4 DIFFERENT TYPES OF ADHD

There are three types of ADHD (Palmer & Finger 2001; Mulder 2010; Graham 2013): predominantly inattentive (ADD), predominantly hyperactive-impulsive (Classic ADHD), combined hyperactive-impulsive and inattentive. Figure 4 shows a spectrum of cognitive disorders along with where different types of ADHD sit in this spectrum[2].

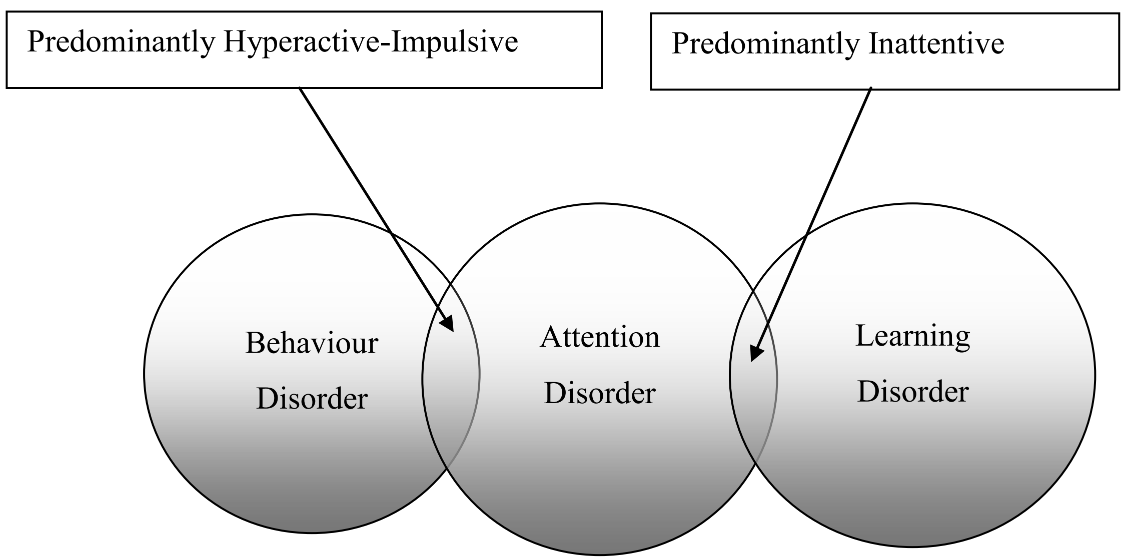


Figure 4: Disorder spectrum

Predominantly Inattentive type of ADHD sits where Learning disorder and attention disorder cross over in the disorder spectrum (Figure 4). The main characteristics of predominantly inattentive children are:

- Easily distracted
- Have difficulty maintaining focus on one task
- Become bored with a task after only a few minutes

[2] www.webmd.com/add-adhd/childhood-adhd

- Trouble completing homework assignments
- Not seem to listen when they are spoken to
- Daydream, become easily confused and move slowly
- Have difficulty processing information as quickly as others
- Struggle to follow instructions

On the other hand, predominantly Hyperactive-Impulsive type of ADHDsits where the behaviour disorder and attention disorder cross over in the Disorder spectrum (Figure 4). This type of ADHD is not hard to be recognized as the abnormal behaviours are easily observable. Typical behaviours of predominantly hyperactive-impulsive children are as follows:

- Fidget in their seats
- Talk non-stop
- Touching or playing with anything and everything in sight
- Have trouble sitting still
- Be constantly in motion
- Having difficulty doing quiet tasks or activities

Finally, the third type of ADHD, Combined Hyperactive-Impulsive and Inattentive, is the most severe type in which children may have a mixture of both constellations of symptoms.

It is important to identify the sub-type of ADHD because as Graham (2013) believes, specific problems are associated to each type. For example although hyperactivity and impulsivity have negative impact on the performance of an ADHD child in the classroom, academic underachievement is particularly associated with inattention (Graham 2013). Therefore, interventions should be designed specific to each sub-type of ADHD to be effective (Graham 2013).

2.1.5 ADHD TREATMENT

So far, many studies have been carried out to help children with ADHD to be able to develop their social skills as well as to control their disruptive behaviours. As a result both medical and non-medical interventions have been evaluated.

2.1.5.1 Medical interventions

Medications have been used for decades to control the symptoms of ADHD. Atype of medication called stimulant are the most effective medical intervention. However, researchers started to study the impacts of other medical treatments such as application of vitamins and minerals on ADHD children. When a child's schoolwork or behaviour improves soon after using stimulants, his/her parents and teachers think medication is all s/he needs. Although these treatments are successful in controlling the symptoms of ADHD, they cannot improve the treatment of affected children for a long-term period(Cho et al. 2002). There are some disadvantages in using medical interventions for ADHD children:

1) Inconsistent implementation of the treatment may cause poor results or even make the symptoms worse (Slate et al. 1998).

2) These treatments are not sufficient to solve ADHD child's educational and social problems completely (Cho et al. 2002).

3) Medical effects are short-term and limited to the period of intervention as discontinuing of medical treatments causes rapid return of symptoms (Slate et al. 1998; Anton et al. 2009; Cho et al. 2002; Alhambra et al. 1995).

4) Not all children respond to medical treatment equally (Anton et al. 2009).

5) There are social and psychological consequences in the future of the children who undertake medical intervention, when realizing their behaviour has been controlled by drugs (Douglas et al. 1976).

6)Medical interventionsare mostly effective in assisting with motor function of ADHD children. However, they are less effective in treating information processing, emotional problems, or high inattentive conditions (Kotwal et al. 1996). Despite the fact that medications help ADHD children to pay more attention in order to finish their homework or learn a subject, they do not improve academic skills. All the same, medications help ADHD children to use the skills they already have more productively.

2.1.5.2 Non-medical Interventions

Several different non-medical approaches have been applied to treat ADHD (Kotwal et al. 1996), such as: self-instructional training, green therapy (taking ADHD child to the nature), music therapy, sensory therapy (massage), working memory therapy, art therapy, aerobic fitness, role playing, cognitive modelling, self-monitoring, self-reinforcement, cognitive and interpersonal problem solving, behavioural therapy (modification), andbiofeedback training (useful in controlling hyperactivity) (Kotwal et al. 1996). Although some of these methods improves ADHD symptoms, Kotwal et al. (1996) believe they have moderate or short-term effects in ADHD children's cognitive and behavioural functionalities. A preferable non-medical treatment for ADHD is behaviour therapy along with operant condition techniques (Douglas et al. 1976; Kotwal et al. 1996).

Klingberg and colleagues (2010) believe that children with ADHD sometimes have problems with working memory. The result of this research shows that performance of the working memory can be improved through training. Training also has a significant effect on motor activity of children with ADHD (Klingberg et al. 2010). Besides, Anton and colleagues (2009) believe that although both medication and behavioural approaches are effective, there still exists some limitations for which some additional strategies and approaches are needed in order to overcome them. National Resource Centre on ADHD promoted Behaviour Modification as the only non-medical treatments for ADHD with a large scientific evidence base. Behaviour Modification intervention consists of different steps which are conducted for the children, parents and teachers.

First step: Evaluation Pre-Test

A comprehensive assessment of children, parents and teachers, is done by a professional psychologist using appropriate psychological tests. Tests are both behavioural and academic and children's state is considered at home, at school and in social settings.

Second step: Treatment Tailoring

Target behaviourswhich need to be considered in ADHD children, are defined in this stage. It can be negative behaviours that need to be stopped or the positive ones which need to be gained. The most problematic behaviour is the lack of social skills namely taking turns, sharing, not being bossy, problem solving and interaction with peers.

An appropriate treatment is tailored by the experts according to the evaluation result, nominated target behaviours, child's age and the socioeconomic conditions of the family which affect the child's performance. This treatment includes different practices that have to be performed by all three partiesin public places.

Third Step: Result Recording

After doing each practice, the therapist records the detailed information in specific forms.

Forth step: Evaluation Post-Test

Another set of tests are done for all three parties to assess the child's progress. According to the results of the post-test the therapist decides whether the treatment can be stopped or needs to be repeated from the second step.

2.1.5.3 Multimodal Intervention

National Resource Centre on ADHD argues that although some families prefer not to take medical interventions for their ADHD child, behavioural therapyis not solely effective without medication (Slate et al. 1998; Trout et al. 2011). Therefore,an integration of medical, educational, and behavioural therapy is needed to treat ADHD. This combinational treatment is called "Multimodal Therapy".

Cognitive Behavioural Therapy (CBT) is an effective multimodal therapy in which therapists work on the cognitive and behavioural problems of children by training both the children and their parents(Anton et al. 2009). CBT consists of three techniques: reinforcement techniques, maladaptive behaviour elimination techniques, and cognitive restructuring technique (Anton et al. 2009).

Nowadays instead of external operant techniques, self-reinforcement and self-control techniques are used for ADHD children which enable themto solve their problems more less adequately(Harris et al. 2005).

2.1.6 DIAGNOSING ADHD

Different types of assessments are used to diagnose ADHD including observation, pen and paper tests, psychological assessment, and finally computerized tests are sometimes used to confirm the diagnosis. The gold standard for diagnosing ADHD is an interview alongside questionnaires such as Conner's Rating Scale (discussed later in the section). However, there are other tools which are helpful in identifying strengths and weaknesses in a child with ADHD but they are not diagnostic. A list of tools used for the assessment of children with ADHD is as follows:

- ***DSM-5 criteria :***The American Psychiatric Association published their own definition of ADHD characteristics in DSM which has been changed over the years from DSM-III-R, DSM-IV(Faraone et al. 2003), and now DSM-V. DSM has been designed for parents and teachers separately and is the most reliable and widely used tool to assess school children (American psychiatric association 2013).

- ***Conner's Parent Rating Scale****:* This scale identifies behaviour problems in children from 3 to 17 and has subscales that assess across the spectrum of ADHD symptoms (Conners 1997).

- ***Conner's Teachers Rating Scale**:* This scale is similar to the parent version with fewer questions that is completed by the teacher of the child to assess a variety of behavioural problems (Goldberg et al. 2005).

- ***Wechsler Intelligence Scale for Children***: This scale which includes 12 subsets, measures different areas of intellectual functioning and provides subtest standard scores and deviations(Weiss et al. 2006).

- ***Test of Variables of Attention Continuous Performance Test***: This test was known as the Minnesota Computer Assessment previously(Alhambra et al. 1995). The first version of this test was released in 1995 and there have been subsequent updates since then.

- ***Trail Making Test (TMT) Forms A and B*****:** This test measures motor speed and visual attention (D'Elia et al. 1996).

- ***Child Behaviour Check List (CBCL)*****:** This checklist includes 113 items which is filled by caretakers in order to assess behavioural problems and social competence of children. This test helps in assessing more general conduct problems(Achenbach 2009). On the other hand, Dreyer (2006)believes that only 6 items on CBCL's checklist directly pertain to ADHD and therefore it is not recommended.

-***Test Of Variables of Attention (TOVA):***This Test is a computerized test that has been developed by TOVA Company located in USA[3]. TOVA, which has been updated several times, measures inattention and its relation to the other parameters. TOVA is an age-and-gender-normalized computer-based assessment of inattention. This test has a lengthy execution time to be completed (approximately 20 minutes), which allows it to measure attention deficits effectively (Braverman et al. 2010). It is a neuropsychological

[3]http://www.tovatest.com

measurement of attention that is used for screening, diagnosis and treatment monitoring of attention disorder in people suffering from autism and ADHD. The company introduced its product as a test which uses a fixed mid-range inter-stimulus interval (2secs) and visual stimuli, similarly to most Continuous Performance Tests (CPT).However, unlike most CPTs, the TOVA stimuli is non-sequential, simple geometric configuration, and monochromatic. The company believes that the mode of response plays a significant role in the reliability of the test. Therefore, instead of using keyboard that is being used in most CPTs, TOVA uses a specially designed micro switch which reduces measurement errors and minimizes muscular fatigue.

Connors Continuous Performance Test: This test is a very simple computer-based test which measures inattention and impulsivity. A single letter is presented in the middle of the screen. If the letter is an "X", the patient should not press the spacebar; otherwise s/he is expected to press the spacebar. Performing this test takes fourteen minutes and an eleven-page report can be produced in accordance with the test(Saklofske et al. 2013).

IVA Computerized Visual and Auditory Performance Test: This test consists of 22 subscales that measure inattention, inhabitation, consistency of response, variability in attention and speed of discriminating reaction time. In IVA a special sound or symbol is shown to the participant. S/he needs to click the mouse or press a button whenever that symbol appears or that sound is played, however, the subject cannot take any other action (Slate et al. 1998). This test can be used for children as young as 5 as well as adults in all ages. It is intentionally designed to be boring, because it is supposed to measure impulsivity, errors of commission, inattention, and errors of omission through a series of tests which demand responding or not responding at certain times. IVA has integrated four types of Continuous Performance Tests (CPT) in one place by means of a counter-balanced design across both visual and auditory modalities as well as facilitating the assessment process. IVA is quite powerful in differentiating the three types of ADHD and assessing the effectiveness of the treatments (Blythe & Laura 2006).

2.2 Problem-Solving Approaches

Goldsworthy and colleagues (2000) have summarized the perspective of different researchers (Bloomquist, 1996; Braswell and Bloomquist, 1991; Kazdin, Bass, Siegal and Thomas, 1989; Kazdin, Esvelt-Dawson, French and Unis, 1987; Kendall and Braswell, 1993) who state that teaching social problem-solving skills has positive impact in producing both near-term and long-term social competence in children.

Different approaches have been designed and applied to teach children how to resolve their everyday social problems. Some of these approaches transfer the teacher's knowledge to the student's brain. Some examples of these approaches are: role playing, demonstration, videotaping, and lecturing. These traditional approaches are not effective enough. They have short-term effect as they do not provide a situation in which learners can practise the learnt lessons in real life. On the other hand, there are other approaches that provide real laboratory environments in which students can practise what they have learnt right after learning through different approaches. Two of these general approaches,which can be used by people with or without ADHD, are discussed below.

2.2.1 SOCIAL AUTOPSY

Myles (2001) suggests social autopsy as a supportive and constructive problem-solving strategy the students can use in order to understand their social mistakes (Myles & Adreon Diane 2001). According to Oxford dictionary, the word Autopsy means: "A post-mortem examination to discover the cause of death or the extent of disease". However, Social Autopsy has been described as "Examination and analysis of a social error to determine the cause of the error, the amount of damage that occurred and to learn about the causal factors in order to prevent reoccurrence in future" in the Oxford dictionary.

Social autopsy is an authentic real-life laboratory. It enables children to realize their errors, the consequences of their actions as well as its impact on other people and on the whole society. Social Autopsy is done in 4 steps (Myles & Diane 2001):

- Identify the error
- Find out who was harmed by the error

- ❖ Determine how to correct the error
- ❖ Develop a plan to prevent re-occurrence of the error in future.

Conducting social autopsy demands the presence of an adult beside the student who is practicing different steps of this approach(Myles & Diane 2001). The developer of social autopsy, Lavoie (1994), argues that children can see the cause/effect relationship between their behaviours with the reaction of the people in their environment to those behaviours. He states that social autopsy is an effective approach forproviding a well-structured practice, immediate feedback, and positive reinforcement.

2.2.2 **SOCCSS**

Situation-Options-Consequences-Choices-Strategies-Simulation (SOCCSS) is a teacher-directed method which developed by Jan Roosa (1995). The aim of this approach was to help students who suffer from social incompetency learn a step-by-step problem-solving method in which they can realize the most appropriate behaviour related to each situation (Myles & Diane 2001). The other benefit of SOCCSS is that students can see the impact they can have on their surroundings based on the decisions they make in different social situations.

This method works in a condition when a social problem happens and the teacher helps the student to go through the SOCCSS steps, analyses the problem, and tries to guide the student to reach to an appropriate action after thinking about the advantages and disadvantages of that action before trying it (Myles & Diane 2001). So far, different researchers and organizations have introduced other approaches based on SOCCSS. POPS[4] and STAR (Goldsworthy et al. 2000) are two examples. POPS stands for Problem-Options-Pick-Solved or Start again. It was introduced by the Centre of Social Success in Dallas by Susan Istre as the baseline of the book series she wrote for children to help them learn social skills more easily. STAR stands for Stop-Think-Act-Reflect introduced by Goldsworthy et al. (2000) as the baseline for developing a video-based application with

[4]http://www.dristre.com/

multimedia scenarios that enhances an adolescent's social understanding (discussed in Section 2.4.6).

2.3 Multimedia Learning

Merriam Webster dictionary defines multimedia as:"a technique (as the combining of sound, video, and text) for expressing ideas (as in communication, entertainment, or art) in which several media are employed; *also* something (as software) using or facilitating such a technique".

Learning, however,is defined as *"*the activity or process of gaining knowledge or skill by studying, practicing, being taught, or experiencing something: the activity of someone who learns" in the same dictionary. Therefore, multimedia learning can be defined as integration of these two definitions as "the process of gaining knowledge or skills by using sound, video and text in the learning practice".

King (1999) states that after inventing motion pictures in 1891, Thomas Edison stated his famous belief about the impact of motion pictures on future education systems in 1922 as:

> *"I believe that the motion picture is destined to revolutionize our educational system and that in a few years it will supplant Longley, if not entirely, the use of textbooks. I should say that on the average, we get about two percent efficiency out of school books as they are written today. The education of the future, as I see it, will be conducted through the medium of the motion picture where it should be possible to achieve one hundred percent efficiency."*

Although after 192 years passed Edison's prediction we have not reached one hundred percent efficiency in educational systems through applying the motion pictures, application of motion pictures as well as other types of multimedia is a part of most of our educational systems. Among different theories and frameworks which have been introduced about multimedia learning,one of the most famous theories is the theory of multimedia learning by Mayer (1991).

2.3.1 COGNITIVE THEORY OF MULTIMEDIA LEARNING

The cognitive theory of multimedia learning, developed by Richard Mayer, is based on three main assumptions: (1) there are two separate channels for processing information: auditory and visual (sometimes referred to as "Dual-Code Theory" which was introduced by Paivio in 1986), (2) each channel has a limited capacity (Sweller's findings on the limitation of human information processing also support this notation) (Mayer & Moreno 2003), and (3) learning is an active process of filtering, selecting, organizing, and integrating information (Mayer 2001).

Mayer (2001) argues that humans can process limited amount of information in their auditory and visual channel at a time. Moreover, humans are able to convert the incoming information into mental representations that they actively create. According to the cognitive theory of multimedia learning, the brain does not interpret multimedia containing words, pictures and auditory information in a mutually exclusive way. Rather, these elements are selected and organized dynamically to build logical mental constructs.

There are five information processing steps involved in the cognitive theory of multimedia learning: (a) selecting relevant words, (b) selecting relevant images, (c) organizing selected words, (d) organizing selected images, and (e) integrating verbal and visual representation according to the prior knowledge.

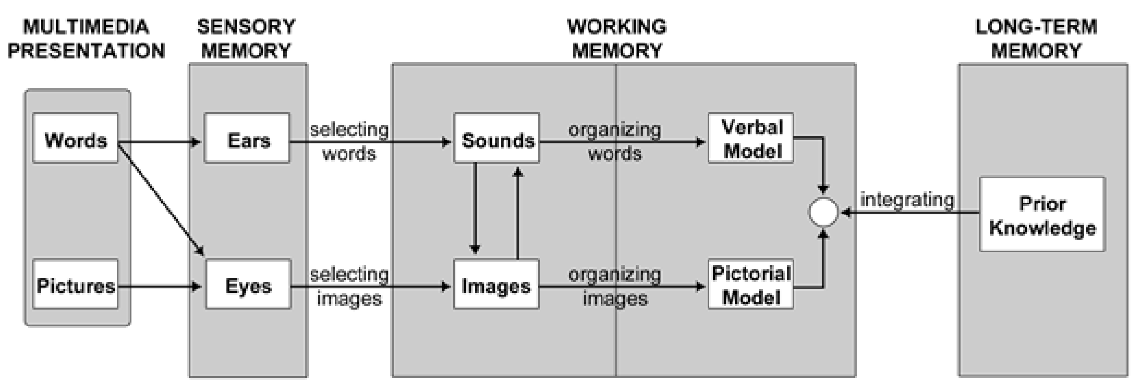


Figure 5: Depiction of the cognitive theory of multimedia learning (Mayer & Moreno 2003)

Figure 5 shows the process of the cognitive theory of multimedia learning where the two rows in the boxes are indications of the two information processing channels in humans and the arrows show the information processing steps.

Mayer narrowed the definition of multimedia presentation down to two forms of information: verbal and pictorial/visual. As a result, Mayer's definition is close to the relevant research in cognitive psychology (Mayer 2001). Cognitive theory of multimedia learning involves seven principles that can be used for the design of multimedia applications. Below are the principles and a brief explanation of them according to Mayer (2001):

"(1) Multimedia principle: Students learn better from words and pictures than from words alone.

(2) Spatial contiguity principle: Students learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen.

(3) Temporal contiguity principle: Students learn better when corresponding words and pictures are presented simultaneously rather than successively.

(4) Coherence principle: Students learn better when extraneous words, pictures and sounds are excluded rather than included.

(5) Modality principle: Students learn better from animation and narration than from animation and on-screen text.

(6) Redundancy principle: Students learn better from animation and narration than from animation, narration and on-screen text.

(7) Individual differences principle: Design effects are stronger for low-knowledge learners than from high-knowledge learners and for high spatial learners rather than for low-spatial learners."

2.4 Pedagogical Agents

Agents are a product of recent technological advances in computer animation and user-interface design. Different studies state that animated pedagogical agents have learning and motivational impact on student's learning (Clark 2005, Mitrovic 2000). Clark (2005) conducted a systematic review of all studies in peer-review journals and conference papers about animated pedagogical agents. Clark's study found three primary types of learning benefits when applying animated pedagogical agents in computer-based instructions: (1) agents may have positive impact on learner's motivation for learning in computer-based learning programs, (2) learners focus on important elements of learning materials when using agents in the environment and (3) agents provide a context-specific learning strategies.Moreover, Mitrovic et al. (2000) situated a simple animated agent called SmartEgg in SQLT-Web. They showed that even a very simple agent like SmartEgg enhanced learning.

2.5 Computer Applications for ADHD

Many software applications with different purposes have been developed to help individuals with ADHD. Some of these applications are used by specialists in order to diagnose ADHD, whereas other applications are designed in order to be used by ADHD people in order to control their symptoms.However, ADHD people cannot live completely free from their problem even by using software applications. For instance,Steiner et al. (2011) developed a computer-based training for ADHD children in order to be used in schools. After conducting an experiment to test the effectiveness of their software, Steiner et al. (2011) found out that parents of ADHD children believe they see fewer ADHD symptoms after the training. This study was one of many that have proved the feasibility and effectiveness of computer-based interventions for ADHD children (discussed in the next sections).

2.5.1 VIRTUAL CLASSROOMS

Virtual Reality (VR) has been increasingly used in psychotherapy and rehabilitation because of having the ability of delivering rich environments as well as predicting and improving daily life. VR has made sophisticated interactions, behavioural tracking and performance recording possible (Anton et al. 2009). VR can help patients hold their attention for longer by being immersive, interactive, imaginable, and interesting (Cho et al. 2002). The most common use of VR in study, assessment and rehabilitation of ADHD is virtual classrooms.

In a research conducted by Cho et al.(2002), a classroom-based virtual environment was developed wherein users were trained to enhance their attention. The idea behind this research is that they believe children spend a long time in the classroom where they should pay attention to the required tasks. The virtual classroom (see Figure 6) has an entrance, a whiteboard, a window, some pictures on the walls, a sofa, a desk with three flags (red, yellow, and violet) on it, and three avatars (a teacher, a friend, and a self-avatar). There were two cognitive sessions provided in the system. In the first session, the self-avatar (which represents the user) sits at the desk with three flags lying down in front of her on the desk and waits until the stimuli are provided. Then the flags are erected one by one. The user should respond to the stimuli when the violet flag is erected. If s/he breaks the rule, a warning sound (beep) goes off in the virtual environment. In the second task, which was a comparison task, two objects were shown on the desk and the user should recognize whether they are identical or not (Cho et al. 2002).

The results of the study of Cho and colleagues (2002) depicted that cognitive training in virtual classroom was more effective than the traditional non VR trainings. However, the cognitive training tasks were not attractive to the users.

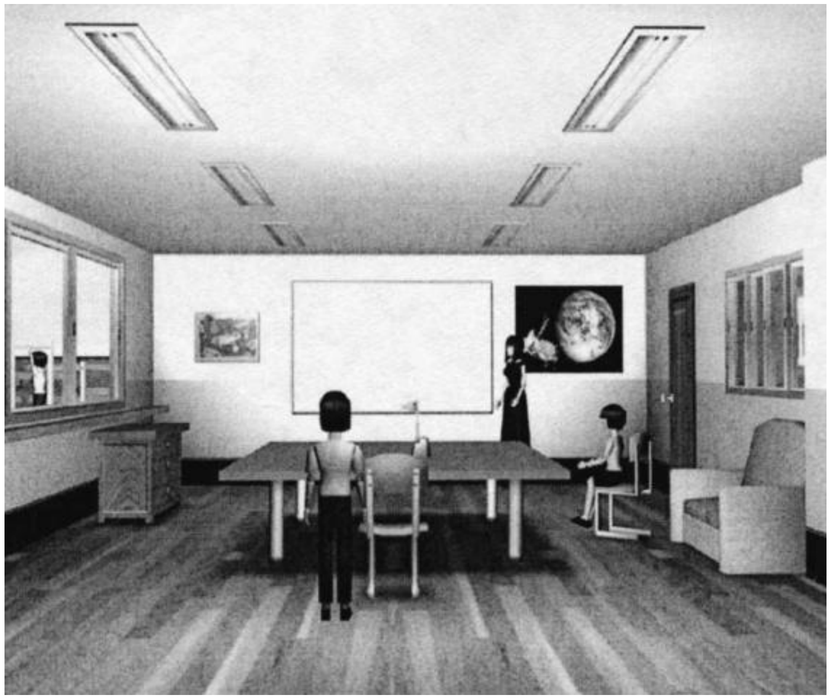


Figure 6: Virtual classroom (Cho et al. 2002)

2.5.2 THINKABLE IBM

THINKable IBM is an integration of software, hardware, and information, which is a useful tool for cognitive rehabilitation, operates on personal computers (Kotwal et al. 1996; Butti et al. 1998). THINKable has different tasks that can be customized according to the patient's treatment plan. In addition to automatic data collection and reporting system, THINKable is able to provide some sets of treatment plans, by which clients can also take benefitfrom some semi-automated therapy sessions (Riccio & French 2010). Feedback is also providedduring the treatment process.

This tool has two sides: a patient side and a clinician side. The patient side is a multimedia program that provides audio and visual stimuli for patients in order to practice cognitive skills (memory and attention). On the other hand, the clinician side is for management purposes. Clinicians can plan future treatments for the patients according to their records and produce detailed reports with the easy-to-use menus (Butti et al. 1998).

In an experiment conducted by Buttietet al.(1998), THINKable was applied for the treatment of 12 mentally impaired elderly patients. As a result, not only did their neuropsychological performance improve significantly, but also there was observed a great improvement in those abilities which had not been directly trained. This study reported a 10% improvement in overall memory after cognitive training by THINKable as well as improvements inself-esteem and visual reproduction during and after the treatment.

2.5.3 CAPTAIN'S LOG

Captain's Log is a cognitive training software designed by Sanford and Browne in 1988 (Kotwal et al. 1996). This software which is a complete computerized mental gymconsists of several modules. These modules provide 50 multilevel programs in more than 2000 hours of game-like brain training challenges (Slate et al. 1998). Kotwal (1998) describes Captain's Log as a computerized system containing a wide range of cognitive exercises designed to help develop attention, concentration, memory, eye-hand coordination, basic numeric concepts and problem-solving reasoning skills. The challenges of Captain's Log are progressive, meaning that the cognitive training tasks have been designed from easy to more advanced ones, suitable for children as young as 6 to adults (Kotwal et al. 1996).

In a study conducted by Kotwalet al.(1995), Captain's Log was used in a case study on ADHD participants. As a result, a significant change in on-task behaviours and a reduction of disruptive behaviours were obtained (Slate et al. 1998; Kotwal et al. 1996). Kotwalet al.(1998), claim that their study provides some helpful evidence for the usefulness of computerized cognitive training for ADHD children.

On the other hand, in another study conducted by Slate et al.(1998), an evolutional trainingwas performed on four severely emotionally disturbed ADHD children. The main aim of this study was to assess the influence of Captain's log on behavioural and performance capabilities of ADHD children. The result presented that the newly-developed skills stay with ADHD children after stopping the treatment. This result was important for dually diagnosed children with two simultaneous, but different disorders. Moreover, according to this study, Captain's log helped ADHD children to enhance non-equally developed skills by means of its multilevel cognitive trainings. This software is available at http://www.braintrain.com/professionals/captains_log/captainslog_pro.htm

2.5.4 FACESAY

FaceSay is a social skills training software with three different games that is designed for mentally disordered children, mainly children with autism[5]. The social skills that FaceSay targetsare recognizing eye gaze directions, emotions, and facial expressions (Hopkins et al. 2011). FaceSay is a multilevel game that includes both easy and difficult tasks. There is a facilitator in the environment that interacts with the child throughout the game. When the child starts the game, his/her name is asked for by the facilitator, which is used later in order to give personalized feedback to the child. Calling users by their names provides a user-friendly environment with which users can interact with the system more easily.

FaceSay provides different tasks in which avatars interact with children and ask them to perform specific actions. The avatars are animated photos of real persons that act upon a pre-programmed knowledge base. Figure 7 shows some snapshots of Facesay. The main aim of using avatars is to provide a more realistic environment by which children can put their learnt social skills into practice easily (Hopkins et al. 2011).

Figure 7: Three snapshots from FaceSay(from Hopkins et al., 2011**)**

Figure 7 is a snapshot of the eye-gaze game in which the avatar looks at an object and asks the user to help her to catch it. The user has to click on the target object. If the user selects the right object, the avatar wears that and thanks the user by calling his/her name. If the user selects a wrong object,the avatar gives an immediate negative feedback and asks the user to try again.

[5] The demo version is available free at this address: http://www.facesay.com/demo.html

Emotion recognition is another goal of FaceSay. Figure 8shows two snapshots of the emotion recognition game. A full face is shown at the centre of the window and different parts of different people's faces are shown on both sides. Then a part of the whole face ismarked and the user is asked to find the appropriate part with the same emotion.

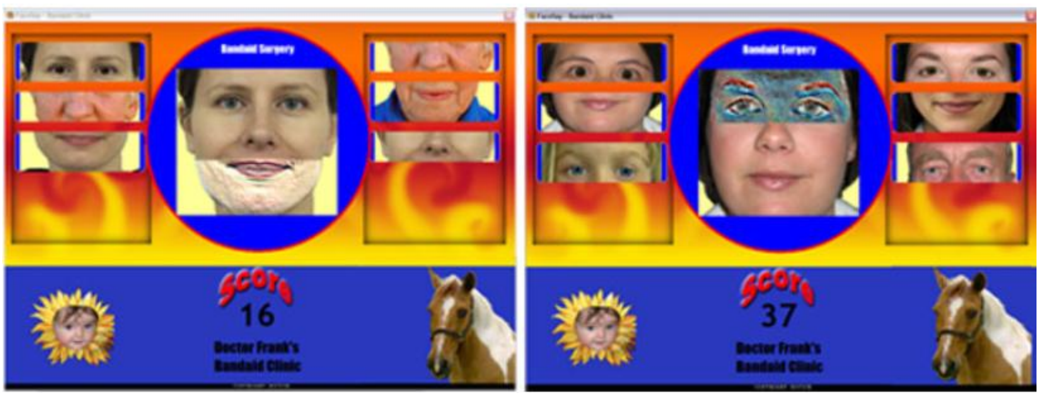


Figure 8: Emotion recognition game (From: Hopkins et al., 2011)

2.5.5 LUMOSITY

At the Lumo lab in San Francisco, researchers have developed an online tool for cognitive enhancement called Lumosity. It offers brain training exercises for people with different level of cognitive skills. People can get mentally fit after working with different well-designed exercises with Lumosity(Hardy & Scanlon 2009). Lumosity gives a customized brain fitness plan to the user. The process starts by asking the user which core brain areas s/he is aiming to develop: memory, attention, speed, flexibility or problem solving and then according to his/her choice, suitable gameis made available for him/her.

Researchers in the Lumo lab claim that according to different clinical trials Lumosity has been able to improve some brain functions such as working memory, visual attention, fluid intelligence, and executive function. Moreover, individuals in different ages can take advantage of Lumosity by applying what they have learnt in the real world.Lumo lab isproud of their product as it has been applied in different scientific and research areas and projects like European Space Agency's Mars500 which is a stimulated trip to Mars (Hardy & Scanlon 2009).[6]

2.5.6 THE STAR PROJECT

STAR,which was developed by Goldsworthy et al. (2000), is a computer game with the aim of developing social problem solving skills of adolescents through video-based multimedia scenarios. We discuss the STAR project in detail, because it is a study most relevant to our research topic so far.

STAR introduced another problem-solving approach that stands for Stop, Think, Act and Reflect. It is based on SOCCSS approach (discussed in Section 2.2.2). Table 1summarizes different steps of STAR.

Table 1: Steps of the STAR problem solving model

Step	Meaning	Action
S	Stop	Get your emotions under control Consider the other person's perspective Define the problem
T	Think	Generate possible solutions Predict the consequences Choose the best solution
A	Act	Do it! Put your plan into action. Accept responsibility
R	Reflect	If your plan worked, congratulate yourself! If it did not, what did work well? What did not? What could you do better next time?

[6] A trial version of Lumosity is available at http://www.lumosity.com/personal-training-plan

The interactive environment of STAR consists of a space academy, three social conflict scenarios and a personal digital assistant help system (Goldsworthy et al. 2000). The space academy is a space exploration training camp in which the learner acts as a rookie who is going to attend the training sessions. The idea is to teach the learner about the learning materials which are embedded in the 3D environment of the space camp. The learner has a full control on his movements. Therefore s/he can learn social skills as s/he explores the space, participates in meetings, meets mentors, and completes assignments. As Goldsworthy et al. (2000) pointed out, the main focus of the STAR project is on the scenarios, each of which consisting of three components:

- A digital video of the socially problematic situation
- A set of background information about the characters in the situation
- A comprehensive guidance provided by a virtual mentor

The developers of the STAR project believe that in contrast to the previous problem-solving models which were mostly group-based or therapist-based, STAR is a technology-based model. Hence, teachers and counsellors can offer the learning materials to children as soon as a problem arises or even before that as a preventive tool. Moreover, instead of one-on-one sessions with the counsellor or group-therapies, many children can get help individually at the same time. Therefore, counsellors can save more time to spend on interventions or assessments rather than dealing with each individual separately (Goldsworthy et al. 2000).

Participants of the STAR project were 59 adolescents aging from 10 to 16 all diagnosed with ADHD. The parents were asked to keep the medication dosage and frequency consistent during the trial. The participants were randomly allocated to three groups each with their specific conditions. The groups were the interactive-software group, the therapist-directed group and the attention-placebo group. The interactive-software group started with a basic training about how to use the interactive software prototype. Then they began to work with the software system in groups of two. This group covered the same materials as the therapist-directed group and then had some role-playing practices. The attention placebo group did not have any training or role-playing related to the social problem solving skills. They were taught about some reading skills and also had some discussions. The subject of these discussions was related to some adolescent issues. A facilitator guided each session to control the participant's behaviour. The frequency of the experiments was twice a week for four weeks. The first and the last sessions involved pre and post-tests respectively. The result of the STAR project was: "the prototype participants performed significantly better than the attention-placebo control group and comparably to the therapist-directed group on one of the two transfer measures of problem solving and on one of the two engagement measures. Moreover no significant differences were found on the Gresham and Elliott Social Skills Rating Scale (SSRS)" (Goldsworthy et al. 2000).

The advantages and disadvantages of the STAR project can be highlighted as below:

Advantages:

- ❖ They looked at ADHD symptoms from a different point of view. So that, they refer to the work of Barkley (1990) and Dunkla (1996) in which both believe that attention per se is not the main problem of ADHD children, instead the key to the ADHD behaviour is a kind of dysfunction in inhibition of responses specially in doing goal-oriented tasks. Goldsworthy et al. (2000), the developers of the STAR project,further supported this idea by referring to the study of Goodman and Poillion (1992). According to Goodman and Poillion (1992), ADHD children and children without ADHD have no difference in attention span and as a result, ADHD children are also able to sustain attention over a long period of time(Goldsworthy et al. 2000). On the other hand, the STAR project wasalso based on Dunkla (1996) which believes the symptom of ADHD is deficiency in timing, pacing and readinessto act. Furthermore, he believes the main problem with ADHD children is intentional not inattention in choosing the right time and right response when performing executive functions (Goldsworthy et al. 2000).
- ❖ The video-based real life scenarios can facilitate the transfer of the learner's knowledge to their everyday life in similar situations.
- ❖ Personal Digital Assistant (PDA) can be helpful as a reference guide for users.

- ❖ Using different virtual facilitators in a fair way has made the software environment user-friendly.
- ❖ Participants interact with peers and the supervisor as well as with the system.

Disadvantages:

- ❖ The discussion sessions after each tutorial with the software system may have positive impact on the user's improvement which makes the effectiveness of the software questionable.
- ❖ The software package was not fully functional in the time of the study.
- ❖ Although the designers of the STAR project tried to develop a comprehensive software system, they could not meet the requirements of a complete software system that is tutorial, practical and assessable. The STAR project did not have any real-life social situation in which learners can imagine themselves in and practically apply what they have already learnt. Therefore, they practiced their lessons in the discussion sessions. Also the need for a teacher or a facilitator was inevitable to teach them how to transfer their knowledge to the real life situations.
- ❖ They did not have enough scenarios. They designed three scenarios but developed just two of them.
- ❖ The user interface was heavily text-based and as a result hard for ADHD participants to interact with the system.
- ❖ The social context was not based on real life scenarios.

2.5.7 **COMAC**

COMAC (edu**C**ati**O**nalga**M**es for **A**DD/ADHD **C**hildren) is a proposed design approach for educational games for ADD/ADHD children (Baghaei et al. 2012). Baghaei and colleagues (2012) argue that many researchers believe that 'flow' (which is defined as the state of intensive involvement) is the key concept in designing successful educational games. Melone (1980) introduced 3 conditions that improve 'flow'. COMAC adds three additional strategies to the Melon's conditions and suggests the following 6 strategies in designing educational games for ADD/ADHD children:

(1) CI: Clear Instruction; there should be clear instructions about what users are required to do from the beginning.
(2) PF: Positive Feedback; the game should provide constant positive feedback in order to show that the user's effort is recognized.
(3) SG: Specific Goals; the user should obtain a certain score before going to the next level.
(4) TS: Think Straight; the user should be encouraged to slow down, analyse the situation, and then move forward.
(5) DS: Display Score; relevant scores should be displayed on the screen.
(6) OB: Organizational Behaviour; the game should encourage children to learn the habit of planning ahead.

The developers of COMAC applied these 6 strategies into two open-source games (Aquaria and SuperTux) in order to make educational games that teach math to ADD/ADHD children. These games have not been tested for ADD/ADHD children to assess their effectiveness yet.

2.6 Games

Kaufman & Sauve (2010) define a game as "a fictitious, fanciful or artificial situation in which players, put in position of conflict with others or against other forces, are governed by rules which structure their actions to reach both a game goal (win) and to achieve learning objectives. Also, the value of a game is not judged by its resemblance to reality."

In contrast to games, simulations are a representation of reality. They are based on a model which does not contain any conflicts or competition, but provide a realistic environment for the user to practice in a risk-free situation. Users of a simulation do not aim to win as in the case of a game. Drawing a clear borderline between definitions of simulation games and educational games has been of a concern for researchers for several years. Kaufman & Sauve (2010) conducted a systematic review on the area and define educational games, educational simulations and simulation games in the learning contexts exactly. They argue that researchers have been using these expressions interchangeably. Therefore, the results of these researches have been divergent and contrived. We discuss the educational games, educational simulations, and simulation games more in the following sections in order to shed more light on their definitions.

2.6.1 EDUCATIONAL GAMES

After conducting a systematic review on definition of games in educational contexts by different researchers, Kaufman & Sauve (2010) found six attributes in common in all of those definitions of educational games: (1) one or several players, (2) conflict, (3) rules, (4) a purpose predetermined by the game, (5) artificial character and (6) the educational character.

A player is the person who makes decisions in the game environment in order to proceed to higher levels of the game or achieve scores. In educational games, an additional role is added to the player's role that is the player also has to learn the learning materials embedded in the game. The players validate their learning by receiving feedback from the game (Kaufman & Sauve 2010). An educational game should provide a decent level of conflict, so that the challenges in the game should not be easy to guess. Kaufman & Sauve (2010) define rules as a set of conditions that describes the relation between the player and the game environment. They also believe that every game has to have a closure condition when the player gains some kind of reward or points or a victory situation. They have called it a predetermined purpose of the game. Educational games have an artificial character as they do not reflect reality. However, they have an educational character as they are used in educational or pedagogical contexts (Kaufman & Sauve 2010).

2.6.2 EDUCATIONAL SIMULATIONS

Simulations are grouped into two types: simulations that are used in engineering and science to examine a hypothesis, and simulations that are used with the purpose of training. In this report, our focus is on the latter type of simulation. Training simulations simplify reality and give the learner the opportunity to practice in the learning environment of the simulation without any hazards that may occur in case of making a mistake (Kaufman & Sauve 2010). Different researchers have defined different attributes for training simulations. After doing a systematic review, Kaufman & Sauve (2010) extracted five essential attributes for training simulations: (1) a model of reality defined as a system, (2) a dynamic model, (3) a simplified model, (4) a faithful, accurate and valid model and, (5) an educational purpose.

Swanson and Orlenas (2001) state that an effective simulation situates the user in a model of a real system where s/he has to take actions and make decisions in order to get real-time feedback. An educational simulation models the reality not by completely conforming to it, but by selecting some elements of the real system. That is because one of the aims of simulations is to simplify the complexity of the real system for the user. The choice of elements depend on what the designer of the simulation is planning to put at the educational simulation (Edwards et al. 2001). The dynamic model is when the user had the ability to manipulate the behaviour of the simulation by selecting different variables. Moreover, the model is a simplification of reality, so the designer ignores some elements of the real system in order to put the emphasis on the other more important aspects and to highlight the essential parts. The designer has to be careful not to sacrifice accuracy and validity of the real system when choosing the elements, developing the educational simulation and simplifying it. The simulation should be as close to the real system as possible, both physically and functionally. However, the model should keep its educational purpose. By educational purpose, we mean the learner should be able to develop a mental model as well as test the model to explain events in the system. Also the model should enable the leaner to discover the relationship among the variables and also to evaluate intangible ideas or dangerous experiences (Kaufman & Sauve 2010).

2.6.3 SIMULATION GAMES

A game does not refer to reality but focuses more on amusing the player. Simulation on the other hand is a representation of reality where users do not aim to win. Designers of the simulation games provide a model of real life and use the feature of games to immerse the players in the model in order to attract their attention and motivate them by means of scoring, performance rating, conflict, and play off. Players can experience and explore in a risk-free environment (Sanford & Williamson 2005). Deciding on the level of reality is not easy for the designers of the simulation games. If they design the virtual environment of the game too close to the real world, they may sacrifice the attractiveness of the game environment. On the other hand, if they focus more on the amusement and give much freedom to the game, they sacrifice the features of simulation (Kaufman & Sauve 2010).

Simulation games inherit some features of both simulations and games and add up the efficiency of both environments in order to develop learning. Kaufman & Sauve (2010) extract seven features for simulation games as a result of a systematic review on different researches in the area: (1) a model of a real or fictitious system that is (2) simplified and (3) dynamic, with (4) players in (5) competition or cooperation, (6) rules, and (7) an educational character.

A simulation game imitates the real life to model a realistic environment. There are one or more players in the environment who take roles and make decisions. The player has to win the game or compete with other players while exploring the environment. The environment is designed based on rules that govern the game. Moreover, a simulation game should retain its educational character in order to support learning. For example by enabling the user to repeat the actions and practice in the environment, knowledge acquisition and understanding of learning materials are supported. When learners are motivated to develop their knowledge, they obtain a positive attitude towards the learning materials. Table 2 indicates a summary of the essential attributes of games, simulations and simulation games. It is seen that simulation games inherit attributes of both games and simulations at the same time.

Table 2: Essential attributes of game, simulations and simulation games(Kaufman & Sauve 2010)

Game	Simulation	Simulation Game
Artificial Character	Reality defined as a system	Reality defined as a system
	• Model • Simplified • Dynamic • Faithful, accurate and valid	• Model • Simplified • Dynamic
• Player(s) • Conflict • Rules • Predetermined goal (to win)		• Player(s) • Conflict • Rules • Predetermined goal (to win)

So far, different types of software systems have been developed and applied to educational contexts in order to help both teachers and learners work more productively. "Drill-and-practice" software systems are an example in which students can review and practice what their teacher has taught them in classroom. Another example of software systems with educational goals are "Edutainment" that look like entertainment application but are designed to teach something to the user in an amusing way. Goldsworthy (2000) believes there is still a gap in transferring the learnt knowledge and skills into everyday life experiments as a result of working with the software systems. An educational software system should fill this gap by providing real-life practices. Otherwise, there should be a teacher or a facilitator who teaches the students how to apply their learnt knowledge in their everyday experience. Goldsworthy states that although drill-and-practice and edutainment software systems may help the student in memorizing or in learning procedural knowledge, they are not useful for a complex and ill-structured learning environment such as social problem solving. Goldsworthy found the reason in Land & Hannifin (1997), who believe in such environments instruction "fails to address the knowledge requirements of a rapidly expanding technological society" as their main focus is on information acquisition and not taking an action in the real world.

The main reason why learners use educational software is to be able to apply the lessons learnt in real life. If the software system does not provide an environment in which the learners can understand how to apply their knowledge to real life situations, learners must understand it themselves. That means using the software system adds some extra meta-cognitive activities to the learner's brain load (Goldsworthy et al. 2000).

2.7 **Concluding Comments**

ADHD is a serious condition that impacts different aspects of the affected people's lives. In order to live successfully in a society, a child has to become well-equipped with different skills. One of the most prominent social skills is problem-solving skill. However, learning is challenging for ADHD children due to the symptoms of their disorder. ADHD children get distracted in traditional teaching contexts wherein students are expected to sit quietly and concentrate on the teacher's narrations. However, ADHD children do not get distracted when playing with computer games, because the environment of the game is both interactive and attractive which causes the brains of children with ADHD to stay awake.

Therefore, computer games showed to provide a high-potential environment that can be used in order to teach different subjects to the ADHD children including social problem-solving skills. A question arises here: how can we make sure that ADHD children are able to transfer what they learn in the game into real world? Reflection on answering this question led to the idea of simulation games with the environment designed according to real world scenarios.

So far, many studies have been done to improve the quality of life of ADHD people. However, none of them provided a comprehensive environment that is designed specifically for ADHD children in order to teach social problem-solving skills to them. With all that mentioned, my project is an attempt to fill this gap.

3. System Design and Development

Design and development of simulation games for children with special needs demand integration of research from different disciplines. Main disciplines are software engineering, psychology and education. In the early stages of our project, we searched for an appropriate authoring tool for developing our game. Choosing an authoring tool that could satisfy our needs was challenging. After spending a few months trying different authoring tools, we realized that each one of them had some limitations that were not able to satisfy our needs. Being not able to find one, we designed and developed our own game. We found Adobe Flash, previously known as Macromedia Flash, a powerful yet flexible tool to be applied in developing our scenarios. In the field of psychology we reviewed research onADHD children and their educational problems and needs. We also researched teaching strategies and chose social skills and social context that are more important for our participants specifically.

Goldsworthy and Sasha (2000) argue that lack of inhibition is one of the struggles of ADHD children meaning ADHD children are not able to inhibit early responses. Therefore when they need to reflect on an action even though they know the right thing to do, they just do not do it. Goldsworthy and colleagues (2000) suggest that the solution to this problem is to teach ADHD children about metacognitive strategies to increase goal-oriented actions and also inhibiting premature response as well as equipping them with appropriate social skills. They emphasise that combining social problem-solving strategies embodied in a stepwise process with social skills training, significantly improves ratings of social adjustment. Our system covers all the requirements of these solutions so that the main aim of the system is teaching social problem-solving skills. We developed animated scenarios wherein children can practise solving social problems step by step in order to gain social competency. The scenarios are goal oriented so that children are expected to solve social problems. Moreover, they also practice inhibition as they have to go through the process step by step and cannot skip any step in order to reach to the final point faster.

Goldsworthy et al. (2000) argue that there are two points worth considering when designing educational games for children. Firstly, instead of shooting and blasting things (which are common in computer games), it is necessary to teach valuable skills that are applicable to their everyday life. Secondly, instead of acting based on trial and error in which children click on different objects randomly to move on, children play the game more thoughtfully by trying to solve the problem in the game.

To clarify our demands from an authoring tool that suits our system development, we needed to ask ourselves some questions. These questions were: In what category our system is situated? Is it an animation? Is it a game? If yes, what type of game it is? Is it a shooting game? Is it an interactive game? What is the main aim of the software? Is it to entertain the users? Is it to teach them something? Will the game involve one-sided teaching from computer to the children or it is an interactive environment? How should it look like for our target group? Should it be simple or complicated? What are our target group's special needs? Thinking of these questions we realized that we need to develop simple animated scenarios. The type of interaction suitable for our targeted group (children aged 8 to 12) consists of pointing and clicking. The environment should be attractive enough to absorb children's attention but not too detailed and complicated to distract them from the main content. Moreover, we needed to be able to design all characters and objects of the environment ourselves in order to adapt them to the Iranian children's everyday environment and therefore the authoring tool needed to be flexible and powerful.

We developed twenty animated scenarios for our system. The number of scenarios was determined based on the number and length of sessions planned for the study. We developed two versions of the system: the English version containing five scenarios with which we did one pilot study in Christchurch, New Zealand, and the Persian version that was fully developed in Farsi (Iranian language) with which we did the second pilot study as well as our main study with Iranian participants.

3.1 The Design Framework

The framework that our system is based upon is the cognitive theory of multimedia learning originated by Richard Mayer (discussed in Chapter 2). Here is a discussion on how we met the seven principles of the theory:

The multimedia principle: Instead of teaching social problem-solving skills by using textbooks, notes or narrations of teachers and parents that are word only resources, we integrated words and pictures in one place in order to help children learn better.

The spatial contiguity principle: Corresponding words and pictures are presented near to each other on the screen.

The temporal contiguity principle: There is different information to be displayed in each scenario of the system:problem definition, solution options, justification options, and feedback. All corresponding words and pictures for each category are presented simultaneously rather than successively. For instance,when the users is asked to click on themselves in order to see the solution options, all pictures and text related to the solution options are presentedat once. Also all the pictures and words related to the justification options presented together after clicking on each solution option.

The coherence principle: Although we aimed to design our simulation game system to be as close to the real world as possible, we kept the environment simple. As a result, we used simple animated characters and objects, we did not load any background sounds, and also no extra explanations were added in forms of written words or narrations. Furthermore, we showed the system to two psychologists in order to get their feedback about the type of words we were using in our system. As a result, we chose simple, understandable words for texts and narrations to use in different parts of the system.

The modality principle: We designed a pedagogical agent which reads problem instructions and feedback for the child. Different studies state that animated pedagogical agents has a motivational impact on student's learning (Clark 2005; Mitrovic & Suraweera 2000).

The redundancy principle: Although according to this principle, students learn better from animation and narration than from animation, narration, and on-screen text, we decided not to follow this principle. The reason is ADHD children are inattentive and as a result they may not follow narration. By presenting the same information also in the textual form, so that the participantcan read the on-screen text when he/she needs that information.

The individual differences principle:Although the users of our system are both children with and without ADHD, our system design is based on ADHD children's special needs.

3.1.1 EMBODIMENT/PERSONALIZATION

The positive effects of providing a self-avatar in the game environment have been proven by different studies. According to (Sanchez et al. 2010), situating a self-avatar (which represents the user in the game), influences his/her feeling of investment within the game. Making the interaction between the user and the system personalized improves learning gain and knowledge retention (Moreno & Mayer 2007). Self-avatars make the game environment personalize and increase the user's emotional attachment to success (Gee 2003).

We implemented an animated character (self-avatar) in each scenario that represents the user. We designed different self-avatars for boys and girls in order to increase the use's engagement with the game.When the child starts a session, the first window presents two cartoon characters: a girl and a boy (Figure 9).

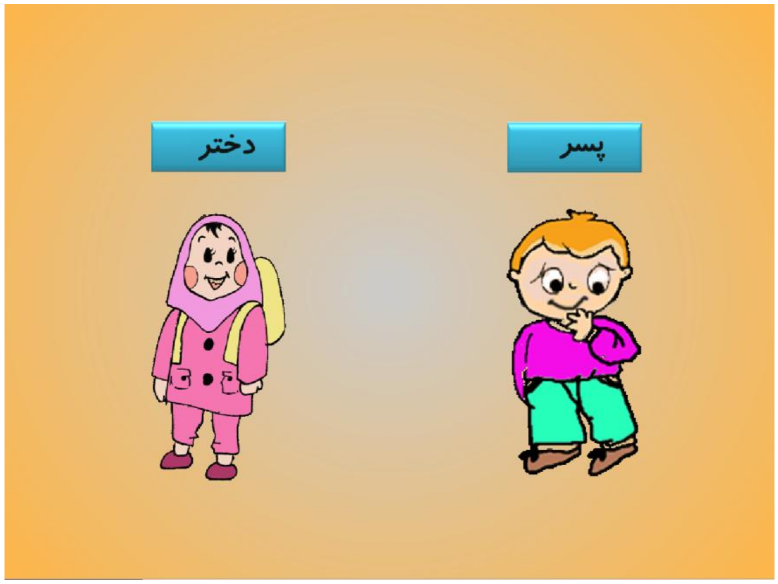


Figure 9: The self-avatars

3.2 Social Skills

Merrell & Gimple (1998) argue that social skills have been defined diversely by different researchers in the field of psychology and behaviour constructs. They reviewed sixteen different definitions of social skills in order to provide a single description for this term. As a result they found social skills among the most widely misunderstood and ill-defined of all psychological constructs. They then referred to the seven components that had been introduced by Sugai, Wood, and Kazdin (1983) to be able to deliver a definition followed by a classification of social skills (Table 3) including: "(1) Social skills are primarily acquired through learning. (2) Social skills contain specific and distinct verbal and nonverbal behaviours. (3) Social skills include both effective and appropriate initiations and responses. (4) Social skills optimize social reinforcement. (5) Social skills are interactive by nature and include both effective and appropriate responses. (6) Social skill performance is influenced by the attributes of the participants and the environments in which it occurs. (7) Deficits and excesses in social performance can be designated and marked for intervention".

According to the mentioned components Merrell & Gimple (1998) defined social skills as follows:

"Social skills are learned, composed of specific behaviours, include initiations and responses, maximize social reinforcement, are interactive and situation-specific, and can be specified as targets for intervention."

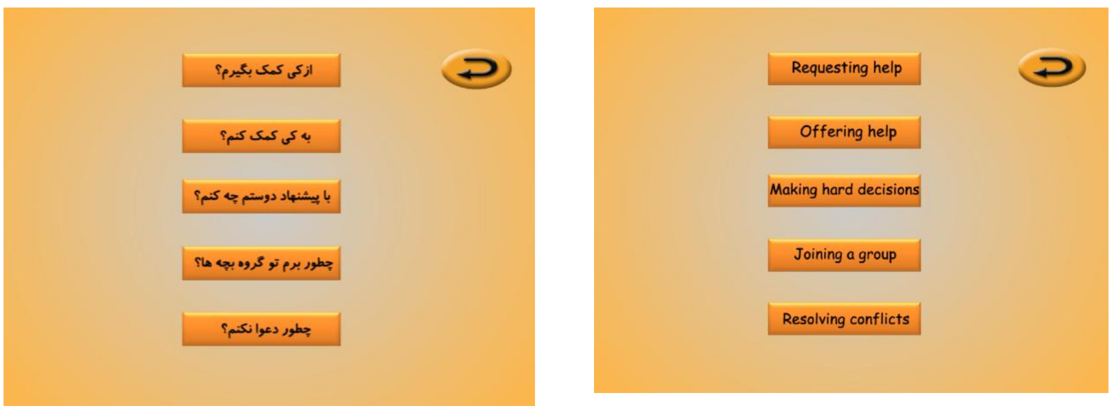
Table 3presents a classification of social skills into four general categories and 30 subcategories (Merrell & Gimple, 1998). The four general categories are self-related behaviours, environmental behaviours, task-related behaviours and interpersonal behaviours. Although they believe that any social skill can be placed under one of these general categories, in order to get more accuracy the categories can also be divided into smaller subsections.

Table 3: General categories and subcategories of social skills

Self-Related Behaviours	**Environmental behaviours**
Accepting consequences Ethical behaviour Expressing feelings Positive attitude towards self Responsible behaviour Self-care	Care for the environment Dealing with emergencies Lunchroom behaviour Movement around environment
Task-Related Behaviours	**Interpersonal Behaviours**
Asking and answering questions Attending behaviour Classroom discussion Completing tasks Following directions Group activities Independent work On-task behaviour Performing before others Quality of work	Accepting authority Coping with conflict Gaining attention Greeting others Helping others Making conversation Organized play Positive attitude toward others Playing informally Property: Own and others

Our goal is not to teach ADHD children about the social skills directly, but instead to teach them social problem-solving skills. In order to teach specific skills, we needed to have some scenarios of real life situations in which children can practice. Instead of randomly choosing real life scenarios, we chose five social skills that cover the four general categories in Table 3. The five social skills that we consider in our system are: (1) requesting help (self-related behaviour), (2) offering help (environmental and interpersonal behaviour), (3) making hard decisions (self-related behaviour), (4) joining a group (task-related behaviour), and (5) resolving conflicts (interpersonal behaviour).

Figure 10(a) is a screenshot of the user interface of the system for social skills options. The buttons are indications of our five social skills respectively.Figure 10(b) is the translation of the same screenshot in English.



(a) (b)

Figure 10: (a) Social skillsoptions, (b) English translation

3.3 Social Context

Social problem solving means solving problems that arise in society. For children, the society is any environment that they interact with others outside their home. We chose four different environments as social contexts where children spend most of their time: (1) school yard, (2) store, (3) classroom and (4) other people's houses. Figure 11 is a screenshot representing four buttons as indications of the four social context mentioned above.

(a) (b)

Figure 11: (a) Social context options, (b) English translation

3.4 Designing the Introductory Tutorial

We developed an animated tutorial to teach children about the six steps of the SOCCSS (discussed in Chapter 4). We represented the six steps of the social problem solving as a staircase with six steps. Children imagine themselves going up the staircase while doing a pre-defined task which is allocated to each step. The task for each step is defined as below:

Step 1: Think of your problem. What happened? Who is involved in this problem? Who was there? When does it happen?

Step 2: Think of any possible solution that immediately comes to your mind. It does not matter whether it is correct or incorrect. Just list all possible solutions. If it is hard for you to find the solutions, you can ask for help from a friend or your family.

Step 3: Bring the solutions you found on step 2 to your mind one by one and think what consequences it may have if you do carry out that solution.

Step 4: According to the results of your thinking on step 3 choose one of the solutions you listed on step 2. Grab your solution and take it to the next step with you.

Step 5: Now you have your selected solution in hand. It is time to make a plan for your solution. How, when and where are you going to do your solution?

Step 6: Now you are standing on the last step. That means you have a solution for your problem and also a plan to do your solution. Go and give it a try. Good luck!

Figure 12indicates a snapshot of the introductory scenario. The child imagines himself on the third step where he has brought the solutions from his thinking on the previous step to his mind. He is thinking on the consequences of each solution before going to the next step.

Figure 12: A snapshot from the introductory tutorial

3.5 The Animated Example

We also designed and developed an animated example of the six steps of problem-solving skill in order to show how children can apply what they learnt in the introductory tutorial in real-life situations. The story is about a boy called Sina who is going to school. It is cold and Sina is wearing a hat. When he gets on the school bus and he takes off his hat, his hair is messy and other children start to make fun of him. He gets upset and puts his hat on again. The school bus arrives to the school and students go to their classes. When Sina enters his class, he cannot stop thinking about what happened on his way to school and cannot pay attention to the teacher. The teacher notices that Sina is not attentive and asks him to take off his hat and listen to the class. Sina does not want to take off his hat and does not know how to reply to the teacher's request. Then he remembers the six steps of problem solving and decides to solve his problem accordingly. Then the animation shows what is going on inside Sina's mind where he steps up the staircase and solves his problem. His solution to this problem is he goes to the teacher and tells him what happened on the school bus. Then he asks permission not to take his hat off, goes to the rest room and arrange his hair and go back to the class with well-arranged hair. Figure 12and 13show snapshots of the animated example.

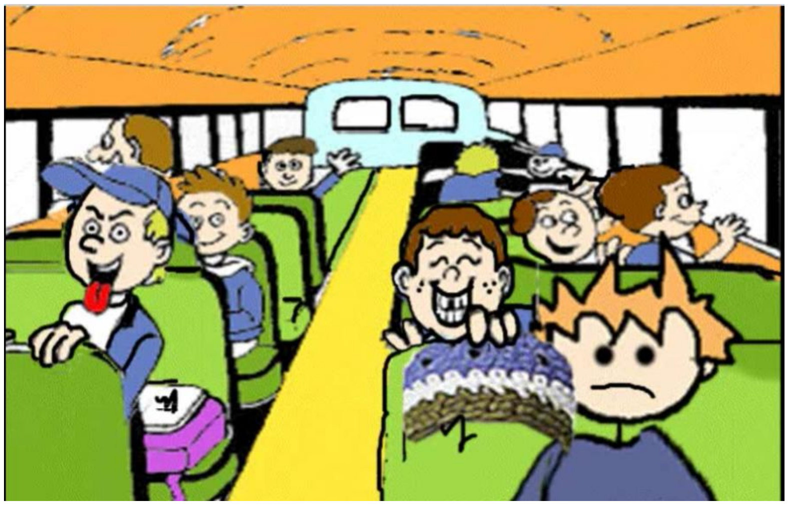


Figure 13: Snapshot of animated example: problem in school bus

Figure 14: Solving the problem using the learnt knowledge from the tutorial

Figure 15: Snapshot of the animated example: problem solved successfully

3.6 Designing the Scenarios

Our system provides 20 scenarios for children to practice the theoretical knowledge they learn in the introductory tutorial and the animated example (four social context and five social skills). Each scenario defines a social problem the child is required to solve. The scenarios have been designed based on children's everyday experiences. The interaction is divided into three phases. In the first phase, we support children's learning by providing everything they need to solve the problem including solution options, justification options and different types of feedback. Children work in the first phase for three sessions. In the second phase, we reduce the amount of support to encourage the child to solve the problem more independently (discussed in more detail later in the Chapter). They work on the second phase for three sessions. The third phase is paper-based and children are expected to solve their problems totally independently. Children work on the third phase for two sessions.

Table 4: Scenarios 1 to 10

Scenario	Social Skill	Social Context	Problem definition
1	Requesting help	School yard	Your mom is supposed to collect you. She's late. You're worried. Whom should you get help from?
2	Offering help	School yard	Students are having their break at the school yard. A child needs help here. Who is he?
3	Making hard decisions	School yard	Your friend suggests you go to a shop outside the school and buy a yummy candy. What is your decision?
4	Asking to join in	School yard	Do you like to join their game? What should you do?
5	Resolving conflicts	School yard	Your friend has been mean to you. You're hurt. What should you do?
6	Requesting help	Store	You've lost your mom. Who is the best person to get help from?
7	Offering help	Store	Which person you can help over here?
8	Making hard decisions	Store	Your friend's suggesting to steal this DVD. He says:" It is too costly to buy, but it is a very interesting game". What should you do?
9	Asking to join in	Store	The shopkeeper is giving free toys to children. You would like to get one too but it seems he can't see you! What should you do?
10	Resolving conflicts	Store	There is just one teddy bear left on the shelf. You and another child both want it. What should you do?

Table 5: Scenarios 11 to 20

Scenario	Social Skill	Social Context	Problem definition
11	Requesting help	Classroom	You did not understand what the teacher just said. What should you do?
12	Offering help	Classroom	There is somebody over here who needs your help who is he?
13	Making hard decisions	Classroom	Your friend says:" This class is boring. I've brought a toy. Let's play some games". What should you do?
14	Asking to join in	Classroom	You are the only one who is not a part of any group. What should you do?
15	Resolving conflicts	Classroom	Your friend does not want to give your book back! What should you do?
16	Requesting help	Friend's house	You're feeling sick. Who is the best person to get help from?
17	Offering help	Friend's house	There is someone whom you can help over here. Who is this person?
18	Making hard decisions	Friend's house	Your friend says:" This party is so boring. I know a park just round the corner. Let's go there!" What should you do?
19	Asking to join in	Friend's house	They're playing your favourite computer game. You really love to play too. What should you do?
20	Resolving conflicts	Friend's house	Your friend doesn't let you to play with his computer. What should you do?

3.7 Elements of User Interface

To have a user friendly interface to demonstrate our animated scenario, we designed a simple yet attractive environment where every element has a specific place which makes the system consistent. As a result, the child can find each component in its pre-defined place, which reduces confusion. On the top of the window there is a green box. The problem is defined in this box. On the right-hand side of the window, there is a pink box.

Justification options are situated at the top of this box, and the lower part is where the pedagogical agent sits and also the immediate feedback he provides for the child on each interaction with the system.

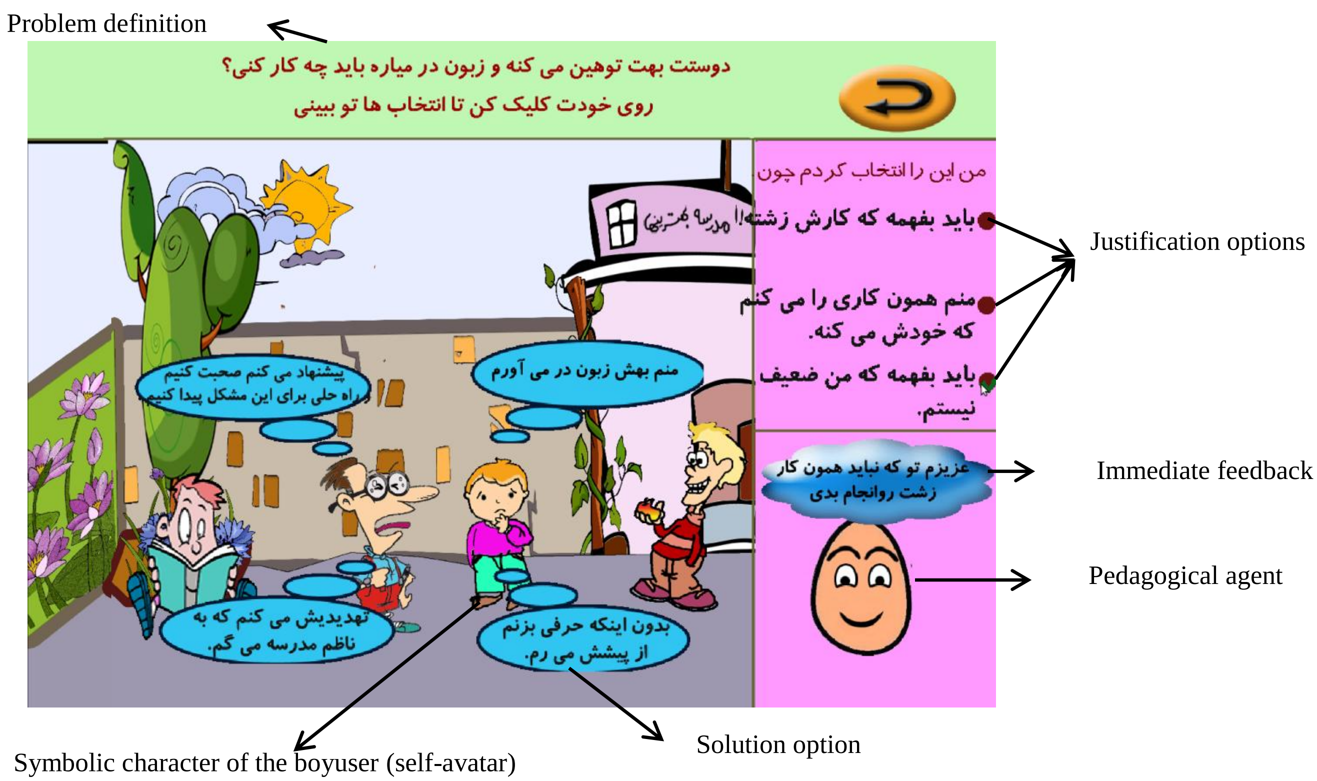


Figure 16: Different elements of a system's scenario

With the aid from psychologists we designed the system’s feedback carefully, as feedback is the central mechanism that helps learners to understand their improvement and regulate their own performance (Sanchez et al. 2010). The rest of the window is where the animated scenario is shown. The animated character of the child and the solution options are also situated in this box. Figure 16 shows different elements of a typical scenario in the system.

3.8 An Example Scenario

To give a clear overview of how the system works,we now present an example scenario and go through it step by step. Our system has two different branches for boys and girls because in Iran boys and girls go to different schools and we aimed to design the social contexts according to their real life environment. In the current example, the participant is a girl. After clicking on the cartoon character, the child needs to select the social contexts (Figure 11). After selecting the social context in which to practise, the child gets the window for choosing social skills (Figure 10). After choosing their desired social skills, they are taken to the main window which is the animated scenario (Figure 16). Figure 17 is a snapshot of the example scenario where the child has chosen requesting help as social skills and school yard as social context. The first thing that the child sees in this window is an animation and the problem text at the top of the window. The agent reads the problem definition for the child and says what is expected from him/her to do. This expectation (which is also presented in the textual form below the problem definition) identifies the object on which the child has to click. In this example scenario the problem definition is:" Your mom is supposed to collect you after school. She is late you are worried. Who is the best person who you can help from? Please click on the proper person". After that the solution options appear. Solution options are of two types. In some scenarios solution options are other people in the environment (Figure 17), whereas in other scenarios solution options are the child's different decisions (Figure 16). In our example scenario solution options are people. Depending on the phase where the child is working different events happen after clicking on each solution option.

Figure 17: People as solution options

The first two phases of the system share the same process until here but they are different from this point. So the rest of the process will be discussed separately for phases one and two in the next section.

3.8.1 THE FIRST PHASE

In the first phase, the system provides strong scaffolding around user's learning process by providing solution options, justification options and precise and detailed feedback. When the child needs to choose one of the options as the solution to the given problem, three justification options appear on the predefined box for justifications. The child has to read through the justification options and choose one of them. On each selection, the agent gives feedback to the child. If the feedback shows that the child is wrong, he has to go back and reconsider what he has chosen. In this case he may choose another justification option or go back to the starting point and choose another solution option. The agent provides three types of feedback: textual, audio and affective.

This is important to keep the ADHD child's sensory channels busy as much as possible during learning. It prevents the child's mind from wondering and keeps the child attentive for longer. Our system fills the child's auditory and visual channels. The pedagogical agent was designed to support the learning process. As a result, the child does not feel alone in the environment. Agent reads the problem definition and guides the children to ease their interaction with the system. The agent also demonstrates different emotions according to the child's chosen options (Figure 18).

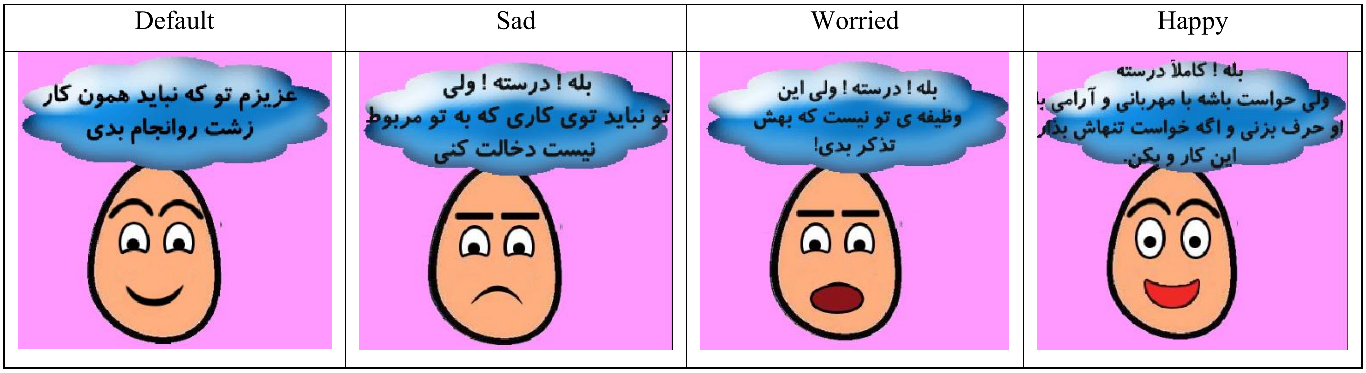


Figure 18: Different emotions of the pedagogical agent

For example, the agent smiles as his default emotion, and becomes sad when the child choses a wrong solution/justification option, or worried when the child makes wrong selections more than three times in a row. Finally, the agent becomes happy when the child solves the problem.

Figure 19 : System's reward for the correct solution

If the child reaches the correct solution, the agent provides positive feedback as well as a star as a sign of the solved problem (Figure 19). On click on this star, the system shows the social context window with the collected start situated at the right corner of the window. The child can go to the same process and solve another problem.

3.8.2 THE SECOND PHASE

Compared to the first phase, the second phase is more complicated. That is because the system provides no justification options but only general feedback and children have to come up with their own justification options. In this phase, when the solution options appear, the agent asks the child to click on wrong options to delete them. On click, the agent is zoomed in so that it occupies the whole scenario and asks the child why the option is wrong. Then the agent counts from 10 to 1 by showing a counter to give time to the child to think of a justification (Figure 20). Theagent is then zoomed out and the chosen solution option is deleted. The child keeps deleting wrong options to have only one option. The only remaining option is what the child has considered as the right answer. If the remaining option is the correct solution to the problem, system rewards the child by giving him a star. Otherwise, a red cross appears and the child is returned to the main window where s/he can choose the same problem or a different problem to solve. Figure 20 is a screenshot of the problem “joining group at friend’s house”. The problem definition here is:” You would like to play with them too. But they do not let you to join them. What should you do? Please click on yourself to see your solution options”. When the child clicks on herself, four solution options are displayed. The system asks the child to delete the wrong solution options one by one and keep the correct solution option. In Figure 20 the child has clicked on one of the wrong solution options to delete it. The agent was zoomed in to the middle of the screen and counting down from 10 to 1 while waiting for the child to justify the reason she thinks her chosen solution option cannot solve her problem.

Figure 20 : Second phase of the system

3.8.3 THE THIRD PHASE

Typing in Farsi with English keyboard is difficult for 8-9 year old children but not for older children. Our participants were 8-12 year old children. Therefore, in order to obtain consistent results, we decided to perform the third phase of our system paper-based for all of our participants instead of paper-based for 8-9 year olds and computer-based for 10-12 year olds. After completing the first two phases, we gave the children an A4 worksheet containing what we expected them to do in the third phase. The work sheet had six sections. Each section conformed to the six steps of social problem-solving process that had been taught to the child in the animated introductory tutorial (Table 6).

Table 6: The worksheet used in phase 3

<u>Step 1</u>: Write the problem you are going to solve here:
<u>Step 2:</u> Write all the solutions that come to your mind for solving your problem (Try to think of four solutions): 1- 2- 3- 4-
<u>Step 3</u>: Now think of the solutions you wrote in step 2 one by one. Imagine what would happen if you do each of them. (You do not need to write anything here. Just think!)
<u>Step 4</u>: OK! According to what you thought in step 3, choose one of the solutions that you like most. Which one did you chose? Write it here.
<u>Step 5</u>: It's time to make a plan for your solution. Think! When are going to do that? Where are you going to do that? How are you going to do that? (You do not need to write anything here. Just think!)
<u>Step 6</u>: Now you have you have a solution and a plan to do the solution. Go and do it. When you finished, come back to this worksheet and answer the following question
<u>Question</u>: Could you solve your problem with this solution? If **YES**: Keep this solution in mind for the similar problems in future. If **NO**: Go back to step 4 and choose another solution and go through the process again.

Figure 21 shows how children were expected to complete the worksheet. After defining problem, they suggest some solution options that they think can solve their problem. Then they choose one of the solution options and try it. If they managed to solve their problem with the selected solution option, they are recommended to keep the solution option in mind to solve possible similar problems in future and that is when the process ends. Otherwise, if the selected solution option was not helpful in solving their problem, they have to check whether they have any untried solution options or not. If yes, they should take the untried solution option and go through the process once more. If no, they are recommended to think of another solution option and try to solve their problem applying that.

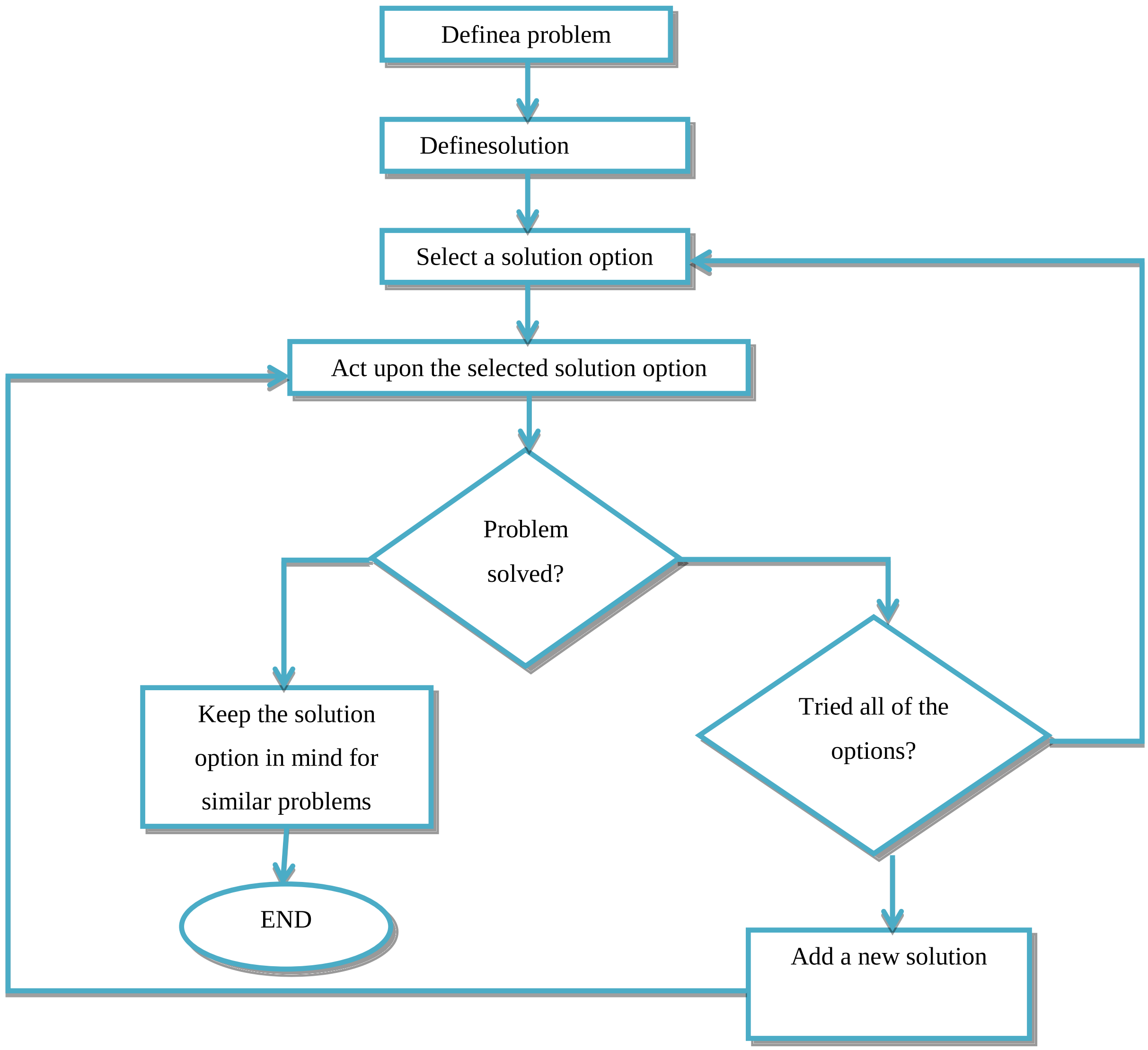


Figure 21: The flow diagram of completing the worksheet

3.9 Software Development

There are some authoring tools such as Adventure Game Studio (AGS)[7] with predesigned animated objects that could be put in the game environment with some drag and drop. The problem with our system was that the characters and objects should be as close to the Iranian children's environment as possible. That meant we had to design all the details ourselves. Therefore we were not able to use the possibility of using predesigned objects in most of the authoring tools.

AGS is an authoring tool for creating point-and-click games. Making and playing games can be done easily with the easy-to-use editor and the run-time engine embedded in AGS. It also consists of a fully customizable interface which speeds up building the more general parts of the game and makes it possible for the developers to concentrate on the unique features of their games more. Setting up rooms and characters can be done visually in the editor followed by some scripts to handle the game events. There is a forum on the Internet in which the AGS users can share their knowledge, discuss different issues regarding their projects and ask their questions directly from the inventor of AGS. After two months of working with AGS we realize it could not satisfy our needs. We did not have much control on the environment. The environment was not attractive enough. The available characters did not move their mouth when talking. We did not have much control on the fonts and their place on the screen.Therefore, we decided to use Adobe Flash 5 and build our game from beginning using the animated objects that are designed and developed by ourselves. Also, Action Script 3 was used as the programming language to control the environment according to our design requirements.

We needed 20 background images and many animated objects to be used in developing the animated scenarios. We started making the characters using Photoshop and Adobe Flash, but it was time consuming and the end product was not ofgood quality. Therefore, we hired an expert in computer graphic to make the animated objects for us. Meanwhile we

[7]http://www.desura.com/engines/adventure-game-studio

used story boarding to get a clear idea about the proper arrangement of the animated objects in each scenario. Story boarding is drawing the story of each scenario using pen and paper.

We named our game TARLAN (simulaTiongAme to impRovesociaLproblem solving of ADHD childrenN). The process of implementing TARLAN is discussed in the next section.

3.9.1 SOFTWARE IMPLEMENTATION

In order to prepare the main workspace of the TARLAN, the main blank screen was adjusted to 1024*768 pixels. The workspace then was divided into four sub-sections (Figure 22).

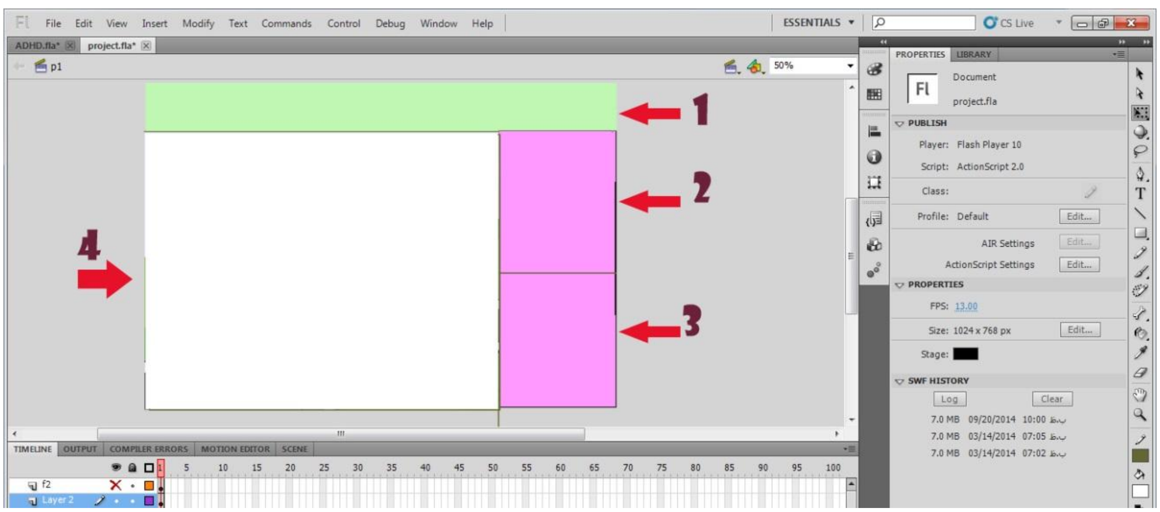


Figure 22: The sub-sections of the workspace of TARLAN

Section 1 is where the problem definition is placed, section 2 is for the justification options, section 3 is the place for the pedagogical agent as well as feedback, and section 4 is where the animated scenario sits.A step by step illustration of designing the first scenario is presented in this section in order to give a clear idea of the development process of our system. The first scenario of the system is requesting help in the school yard. A screenshot of the end product of this scenario can be seen in Figure 17. In developing each scenario, we had a background image and some animated objects that were placed on the background image. Therefore, the first step was to place the background image on the workplace (Figure 23).

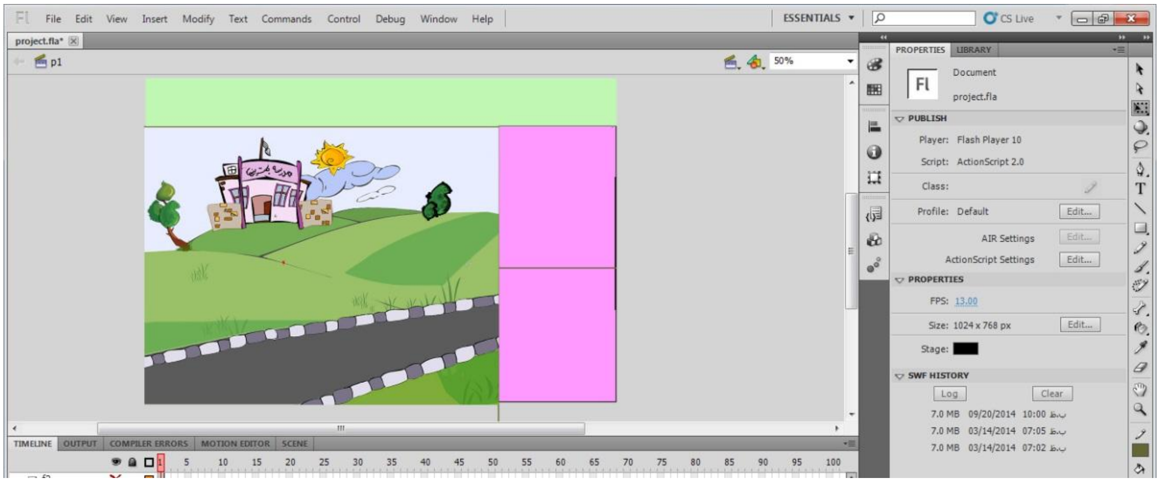


Figure 23: The first step (placing the background image)

The next step is to place the animated objects on the background image. The red box in Figure 24shows where the couple are placed on the background image.For each animated object we put a boxwith the same size and in the format of “Movie clip” on the image.

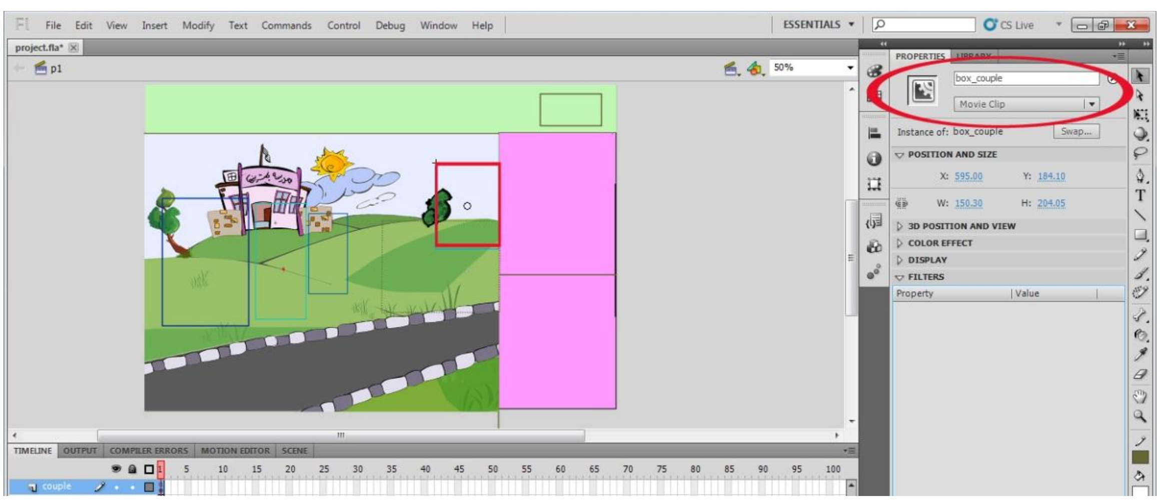


Figure 24: Placing the animated objects on the screen

We had many audios, videos and pictures in the system. The loading speed would decrease if we embedded all animated objects in the software. Instead, we kept all the animated objects in a separate folder. Animated objects were loaded to their allocated boxes on the background image when needed. The function that is used to load any kind of multimedia object to the screen is “LoadMovie”. In some parts of the scenario (such as problem definition and feedback), we have both on-screen text and narration. These two have to be loaded simultaneously. For instance, for the problem definition, a box of the type MovieClip was situated on top of the screen. The text of the problem definition was saved as a “gif” file and the narration was saved as a “swf” file. On entering the scenario both files were loaded to the considered box with the “loadMovie” function (Figure 25 and Figure 26).

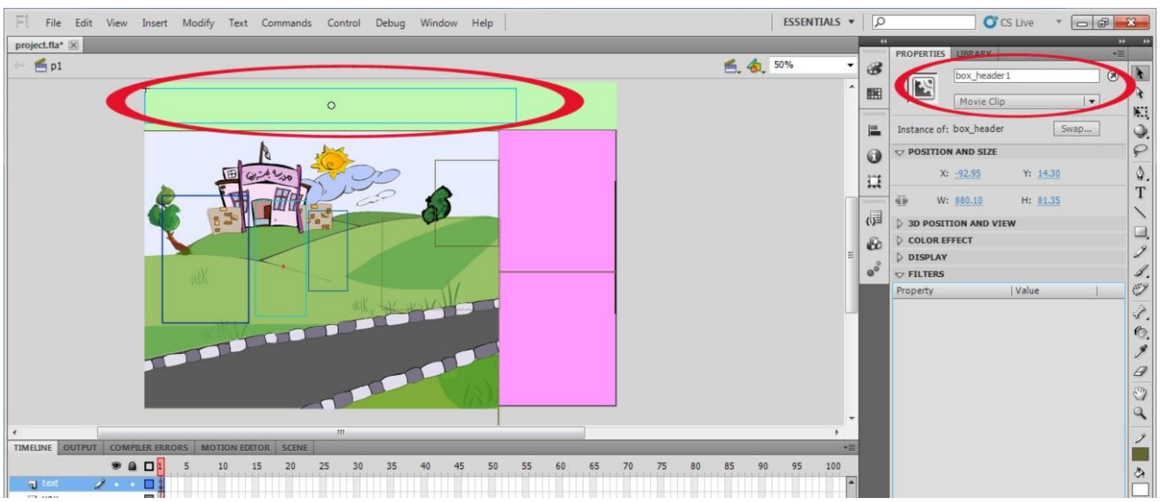


Figure 25: Preparing the scenario for playing narration and text

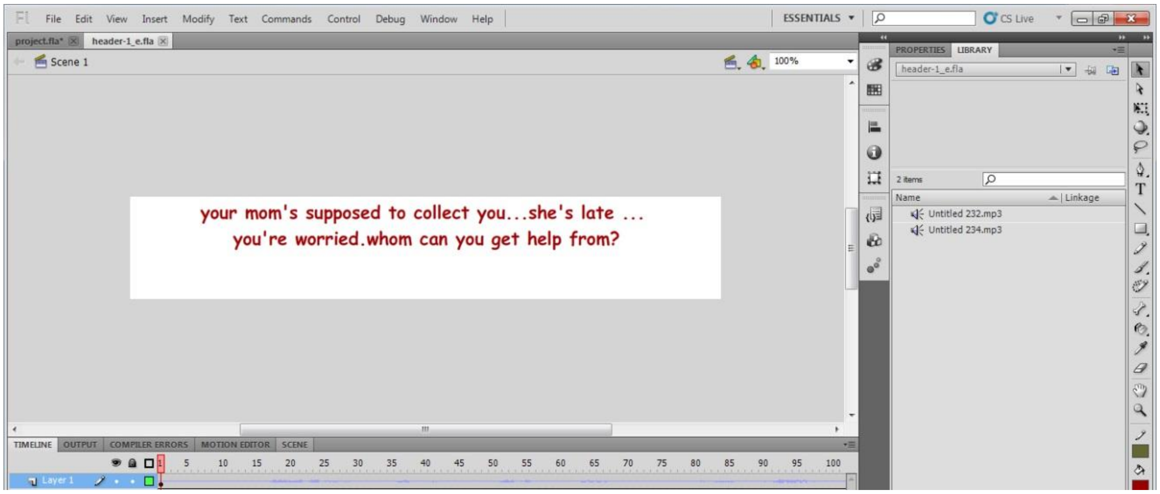


Figure 26: Placing text and audio on the scenario

The process of loading the solution options is similar to loading of the problem definition. Our system is a point and click system, so that there should be different actions according to different clicks of the participants. As a result, some of the objects of the environment such as solution options and justification options should be clickable. Therefore, the clickable objects were converted into buttons.

Behind every solution option there was a code to load the corresponding justification options in place. For instance when the user clicks on the "couple" in the first scenario the following code is run:

loadMovie("img/text_couple1_s1.gif", "box_text_click1_s1");

loadMovie("img/text_couple2_s1.gif", "box_text_click2_s2");

loadMovie("img/text_couple3_s1.gif", "box_text_click3_s1");

Beside each justification option there is a squared box. On each click on the justification option the squared box beside it is ticked while the other two justification options are without tick. The following code is shows what happens when the user clicks on the first justification option:

unloadMovie("box_tik2_s1");

unloadMovie("box_tik3_s1");

loadMovie("img/tik.gif", "box_tik1_s1");

The related feedback to each justification option is loaded on clicking on each justification option. The feedback is the most complicated component to be loaded as it encompasses on-screen text, narration and the pedagogical agent's different emotions. The following code shows the code for loading the feedback for the first selected justification option of our example that is a wrong justification option and the pedagogical agent is sad:

```
if (_character_s1 == 2)
{loadMovie("img/f1_s1.swf", "box_feedback");
    agent_defult._visible = false;
    agent_narahat._visible = true;
    agent_narahat.play;()}
```

When the users solve a problem, in addition to the positive feedback, they are given a star as reward. They click on the start to collect it as well as exiting from the environment of the solved problem. The visibility of the star is false until the user manages to solve the problem (Figure 27).

Figure 27: Coding the reward for the solved problem

The star will be visible after 15 seconds to let the user to listen to the feedback without getting distracted with the reward.

4. Experiment Design and Data Collection

Designing an experiment depends on the nature of study. Answering some questions may help in clarifying that nature. How many groups are there in the experiment? What method to use for allocating subjects to the groups? Are the subjects humans? How large is the sample size? In our study we had one experiment group and two control groups. The subjects were humans and the sample size was medium. When subjects are humans, there are some external variables that may impact the results. The external variables can be age, gender, socio-economic state and so on. We applied the randomized controlled design to reduce the influence of external variables. A randomized control trial allocates subjects to the different groups of study randomly. It removes the effect of the external variables without the researchers being aware of them. Therefore the researcher cannot have any conscious or sub-conscious bias on allocating participants to the groups[8].

The study was agreed to be conducted in Iran, because logistically it was easier to find 40 ADHD children in the particular age group in the larger population of Iran and also faster to collect data. Therefore Human Ethics approval was needed from both New Zealand and Iran before conducting the study (the application and approval are given in AppendicesA and B). Sixty children aged 8 to 12 were recruited to participate in the study from which, 40 were children with ADHD and 20 were children without ADHD. We allocated the children to two interventions: a computer-based intervention and a psychotherapist-directed intervention (discussed in Sections 4.2 and 4.3). Participants were selected by a psychologist who informed his colleagues working in other clinics in the same field of his about our study and asked them to introduce patients who match our inclusion criteria to us. The main advantage of this process was that all participants had already been registered in psychological clinics and had been diagnosed as having or not having ADHD. All children had social skills deficit. However, children without ADHD had undergone a test by their psychologists or psychiatrics to make sure they have social skills deficit.

[8]https://explorable.com/randomized-controlled-trials

4.1 **Pilot Study**

Two pilot studies were performed before conducting the main study. The main aim of conducting the pilot studies was to involve children with ADHD in some design decisions. The first pilot study was done in New Zealand. The system was in English including five animated scenarios.The environments of the scenarios were based on New Zealand's culture. The solution options were human characters in all of the scenarios. One boy with ADHD participated in the experiment. He went through all scenarios and solved the social problems defined in them. A psychologist was present in the session, who observed the child while working with the system. The psychologist was not allowed to interfere in the child's work or provide any comments. At the end of this pilot, we found the problems not challenging, because the child clicked on the solution options one by one without thinking. As a result, we decided to design another type of problem wherein solution options are the child's thoughts in on-screen text format.

The second pilot study was conducted in Iran because we decided to conduct the main experiment in Iran.We designed and developed 8 scenarios in Farsi, 4 problems wherein solution options were animated human characters, and 4 problems wherein solution options were the child's thoughts. The problems covered two social skills and four social contexts. The social skills were "requesting help" and "joining a group". The social contexts were: school yard, store, classroom, and a friend's house. Problems were designed for both the first and second phases separately. Five ADHD boys were recruited (aged 8, 9, 10, 11 and 12) to work with the system for two sessions, one session in the first phase and the other session in the second phase. The session supervisor observed the children while working with the system and asked them to speak up their minds. The supervisor took notes about children's feedback and her observations. At the end of the second pilot study, according to the gained feedback, we decided to change some parts of the design of the system. The first thing we changed was some of the words in the text to make them understandable for younger participants in our targeted age range (8-12). Furthermore, the pedagogical agent had an extra emotion, which was getting angry when the child made three wrong selections in a row. The psychologist suggested removing this emotion as it may discourage ADHD children. Also, we changed the design of the second phase of the system after the pilot study. In phase 2, when a child clicked on a wrong solution option in order to delete it, the solution option was deleted immediately. As participants were expected to justify their selections, the psychologist suggested leavinga few seconds between clicking on the wrong solution option and the actual deletion from the screen. As a result, we changed the second phase so that when the user clicks on the wrong option, the agent counts down from 10 to 1 to give the user 10 seconds to justify him/her option.It was also observed that problems with human characters as solution options are easier to solve for ADHD children compared to the problems with text-based solution options. Finally, the session length was confirmed to be between 20-30 minutes after the pilot study.Consequently, we conducted the pilot studies and changed some parts of the system according to the feedback which were collected during the pilot studies to make the system conformed to ADHD children's special needs.

4.2 Experiment Requirements

There were several inclusion criteria for the study: (1) all children in the ADHD group children had to have ADHD, combined presentation (discussed in Chapter 2), (2) there could not be the presence of other comorbid disorders such as depression, anxiety, and bipolar disorder, (3) all of the ADHD children had to be taking medication at the time of the testing and the dose type of medication could not change during the study, (4)participants could not receive any kind of training regards social skills outside of our allocated intervention during the experiment. ADHD children with bipolar disorder, dyslexia, mood disorder, auditory problems or borderline IQ were excluded from the study whereas ADHD children with other types of learning difficulties such as dysgraphia or dyscalculia were kept in the study. Figure 28 presents the CONSORT diagram[9], a diagram that illustrates how the participants flowed through the study.

[9]http://www.consort-statement.org/consort-statement/flow-diagram

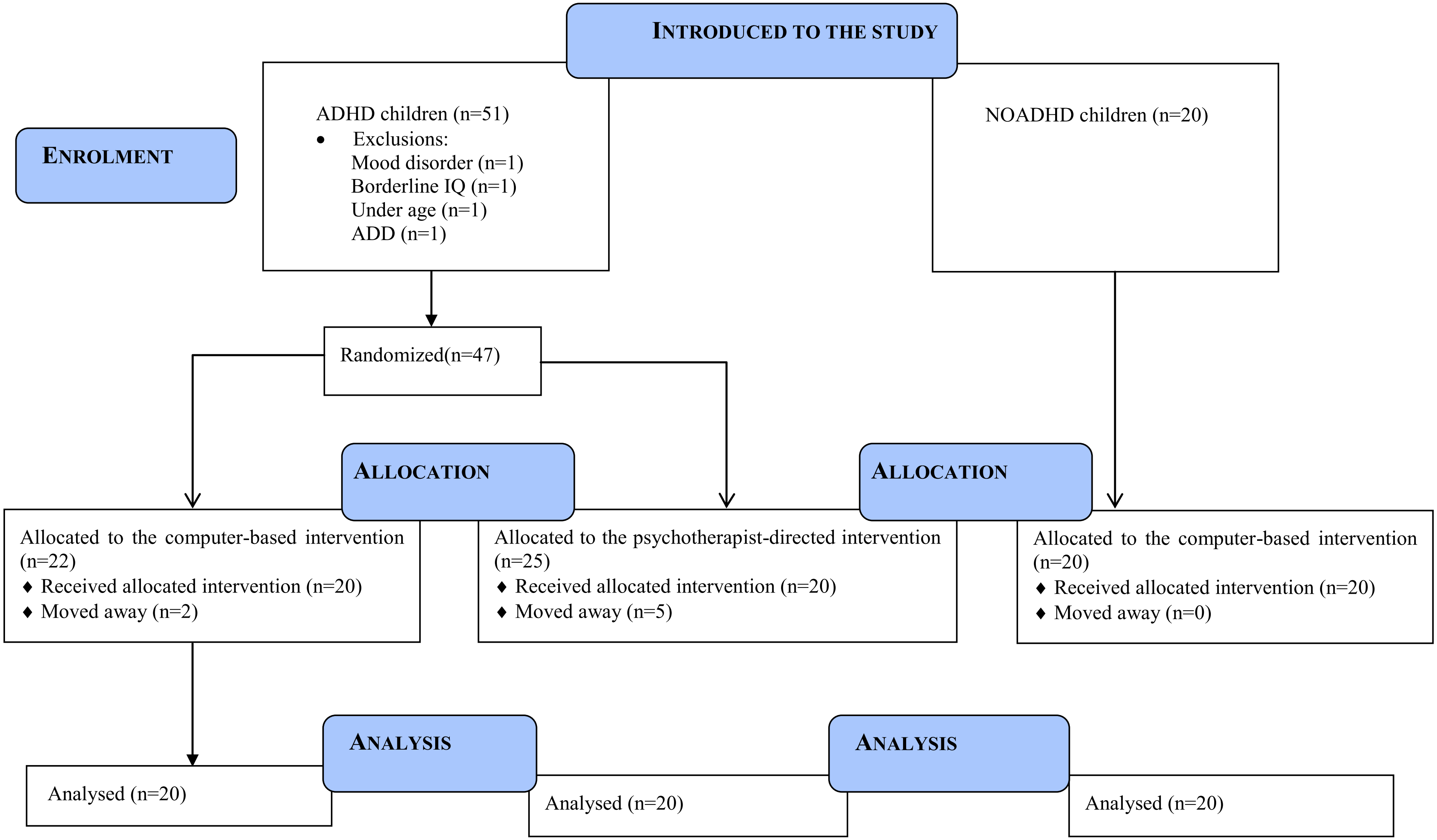


Figure 28: CONSORT flow diagram

A total of 71 children were introduced to our study. From them, 51 were ADHD children and 20 were children without ADHD. Four ADHD children were excluded from our study because one was under age and three had been diagnosed with mood disorder, borderline IQ and Attention Deficit Disorder (ADD). The assumption for ADHD children is they all lack social skills unless they had taken any tutorial regarding social skills outside the study.

The 20 children without ADHD were allocated to the computer-based intervention directly (NOADHD group). The remaining 47 children with ADHD were randomly assigned to the interventions. Twenty two children were allocated to the computer-based group (ADHD-Com group) and 25 children were allocated to the psychotherapist-directed intervention (ADHD-Psy group). Two children from the computer-based intervention and five children from the psychotherapist-directed intervention chose to move away from the study. Therefore we had 20 children in each group who successfully completed the study.However, the type of our study was Randomized Trial with parallel design. That means we had to assign our participants to the groups randomly.

The location of conducting the study was the NasimBamdad Clinic in Iran. All sessions, including the group meetings of the psychotherapist-directed intervention, took place in the same room. When children sat at the computer, they faced the wall. There was another desk for the supervisor behind the child's desk. We set the room as described because we aimed to minimize distractions as well as being able to observe the child. As the study was done individually, we tried to keep the setting constant to everyone including lighting, temperature, quietness, decoration and equipment.

We anticipated that the participants might be stressed in the first session, because some of them did not necessarily understand what exactly we expected them to do. A clinical psychologist was available during all sessions of the study. The supervisor monitored the participants to make sure they were doing fine, and intervened if necessary. Parents were allowed to stay with their children if they wished so, but were not allowed to talk to their children or to the supervisor during sessions. All mobile phones had to be switched off inside the room. Each participant was assigned an ID, and the data related to him/her were kept under that ID. During the study, all information was stored on the main researcher's computer (not shared), located in the study room, which was password protected. The written information was also kept in a locked drawer in the same room. The researcher and the associate supervisor were the only people who were aware of the password and had access to the locked drawers. When we finished the study, we moved all information to the locked drawer in the ICTG lab at the University of Canterbury. Only the researcher and the senior supervisor have access to the data. For children and young adults, we provided an information sheet and a consent form although consent for their participation was sought from a parent/caregiver.

As discussed previously, one of the goals of our study was to provide social contexts as realistic as possible so that the participant could see himself/herself as a symbolic cartoon character in the social context. In designing the system for Iranian participants, the need for cultural considerations was unavoidable. Boys and girls go to separate schools in Iran and girls have to wear scarves in school as a part of their uniforms. Our system met these cultural requirements.

4.3 Experiment Design

The study consisted of 8 sessions (two sessions per week). For the computer-based streams, each session took 20-30 minutes and for the psychotherapist-directed group it took 50 minutes. Children in the computer-based streams worked with the software individually, whereas the psychology stream conducted group sessions where ADHD children learned about social problem solving skill by a standard psychological approach called role-playing. As indicated in Figure 29 the study started by conducting pre-tests for both the children and their parent. SSIS (Social Skills Improvement System) Rating Scale was used as pre/post-test (discussed in Section 4.5). Children without ADHD and 20 ADHD children who were allocated to the computer-based intervention worked on the first phase of the system for 3 sessions, on the second phase for 3 sessions and on the third phase for 2 sessions. The other 20 ADHD children who were allocated to the psychotherapist-directed intervention worked as groups of 3 to 5 persons on role-playing. At the end of both interventions, the children and their parents conducted post-test.

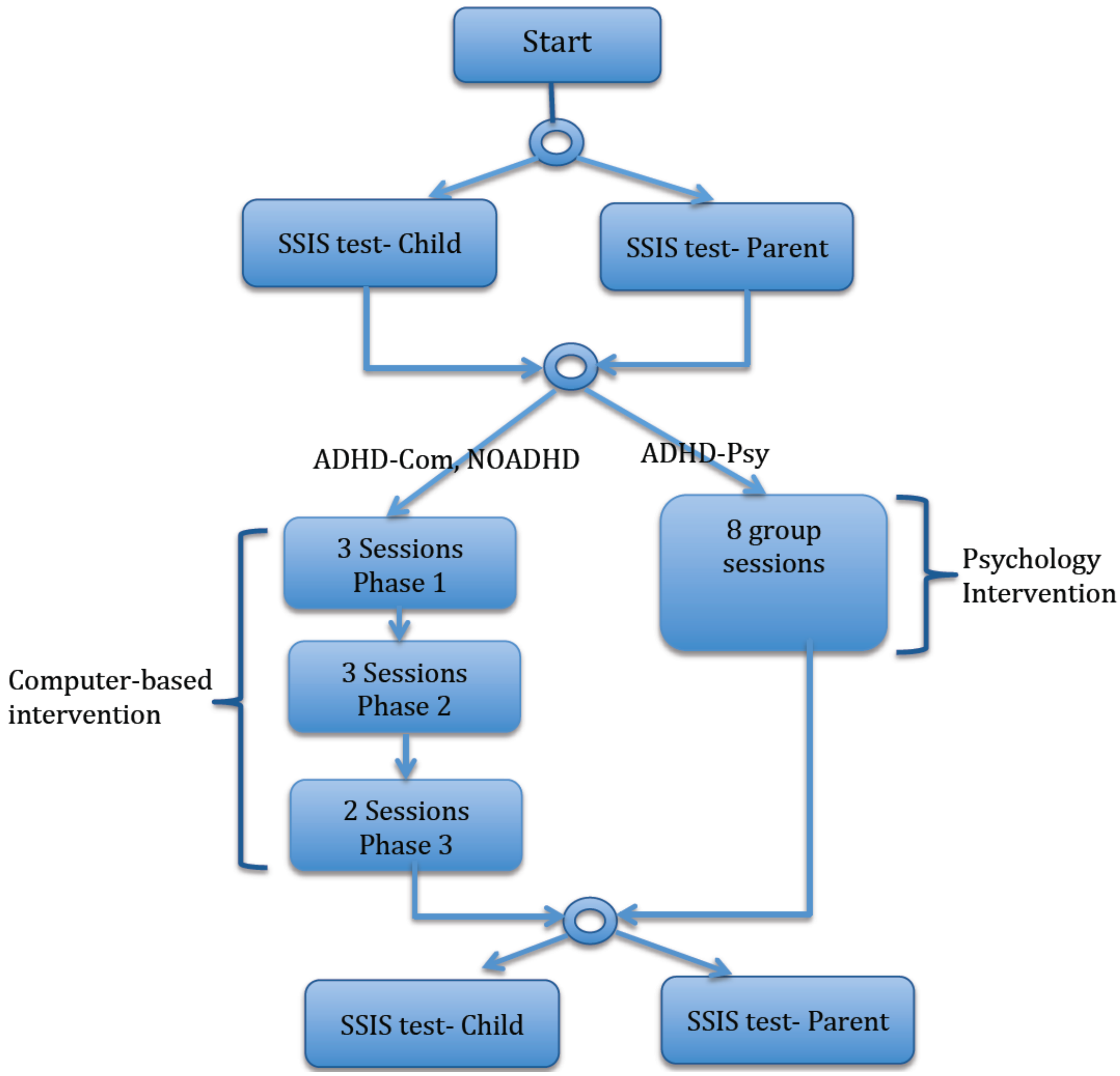


Figure 29: The experiment design

4.3.1 THE COMPUTER-BASED INTERVENTION

The computer-based intervention contained eight sessions. Below is a description of the activities that were done in each session:

Session 1:Pre-test was conducted for both the child and the parent. The supervisor gave detailed instruction of working with the first phase of the system to the child by solving the one of the problems with him. After that the child watched the introductory tutorial followed by the animated example. The child was free to work on the first phase for the rest of the time.

Sessions 2 and 3: The child watched the introductory tutorial and the animated example followed by working on the first phase for the rest the time.

Sessions 4 and 5:The supervisor gave detailed instruction of working with the second phase of the system to the child by solving one of the problems with him.The supervisor also encouraged the participants to watch the introductory tutorial and the animated example if they wished so.

Session 6:The activities in this session were similar to the sessions 4 and 5. At the end of the session, the supervisor handed over an A4 worksheet for the third phase of the system to the child and explained all the sentences to him.

Session 7:The child handed the worksheet back to the supervisor. The supervisor went through what the child had done on the worksheet while sitting next to him and gave necessary explanations. Then the supervisor handed over another A4 worksheet for the third phase to the child. The child was allowed to watch the introductory tutorial or the animated example if he wished so.

Session 8:The child handed the worksheet over to the supervisor and undertook post-test. The parent also did the post-test

Boys and girls used different versions of the system, as explained earlier, due to cultural issues. Then they were free to explore the environment and work how they liked.

They could watch the introductory tutorial or the animated example as many times as they liked. The participants could work in any social context or on any social skills they wished. The child could stop working with the system after 20 minutes. However they were not allowed to work with the system for more than 30 minutes. If for any reason the child decided to work less than 20 minutes, the supervisor kept the time and allowed him/her to have a quick rest and then come back and continue working with the system.

4.3.2 Psychotherapist-directed Intervention

The psychotherapist-directed intervention consisted of eight group sessions. The participants worked in groups of three to four. A psychologist with a Master's degree led the sessions. Social problem-solving skills were taught by means of a traditional psychological approach called "Role playing". In role playing, children pretend they are in a particular social context and practicing problem solving in that context. There was a written protocol prepared that defined the activities in each session in detail. The social skills and social contexts in the psychotherapist-directed intervention corresponded to what we had considered in the computer-based intervention.

4.4 The Role of Psychologists in the Study

There were two psychologists who directly helped in conducting the experiment: the associate supervisor and the session supervisor. The associate supervisor was responsible for finding children with ADHD who meet the requirements of our study. Also he was present in the clinic while the sessions were being run. Moreover, the associate supervisor was responsible for designing the psychological intervention which was done parallel to the computer-based intervention. He also controlled the sessions randomly to make sure everything is in place.

On the other hand, the session supervisor was another psychologist who stayed with the children in the experiment room while they were working with the system. We had a training session for her to get her familiar with the computer-based intervention, the software and also to inform her about her responsibilities. The supervisor configured the system for each session. The configuration includes setting the student ID and getting the screen capture application ready for the child to start the session. Her other responsibilities were keeping track of time to make sure every child work with the system for 20-30 minutes, turning on the screen capture application at the start of the session and turning it off at the end of the session and saving the screen capture file with the student ID and date and logging out the student. The session supervisor was not allowed to help the child in solving the problems. However, she could guide the children to go to a specific step if they asked. Moreover, she could help the children in other inquiries such as going to toilet, needing to see their parent or other issues that might arise. In such cases the supervisor had to pause the screen capturing and run it when the child returned and sat at the computer again. The session supervisor also administered and scored the SSIS test.

4.5 Social Skills Improvement System (SSIS)

We used the Social Skills Improvement System (SSIS™) Rating Scales to measure improvement of social skills of ADHD children. SSIS is a revision of the widely used Social Skills Rating System (SSRS™; Gresham & Elliott, 1990). It is a standard test that screens and classifies students with social skills deficits and helps in intervention planning for those students. SSIS also assess problem behaviours that may have impact on the student’s social skills acquiring and performance. Gresham & Elliott (2008) believe that problem behaviours interfere with either the acquisition or performance of socially skilled behaviours. There are three different versions of SSIS for teachers, parents and students. Therefore a student’s social skills and problem behaviour can be rated by teachers, parents and the student to obtain precise information about the student from different perspectives.

SSIS classifies results as indication of social skills strength, performance deficits and problem behaviours that may interfere with the student’s ability to learn or perform social skills. It is done by applying national norms that simplifies identification of the social skills and problem behaviours. An intervention planning section is then conducted immediately after rating section. It is an instructional tool that helps practitioners to develop an intervention plan that they consider helpful in the student's development process towards gaining social skills. This plan can be done more conveniently as the practitioners have the ratings in front of them and can build their intervention plan according to that. The direct link between the rating section and the intervention plan has made SSIS test a user friendly tool for practitioners.

There are some features that have made SSIS Rating Scale a comprehensive and reliable approach to social skills assessment (Gresham & Elliott 2008). The structure of SSIS is research based so that unimportant and offensive items were eliminated through content and bias reviews. As a result the items included in SSIS are representative of and relevant to the key behaviours. It can be administrated and completed quickly and easily as forms are brief yet provide sufficient sampling of important behaviours. That is because designers of SSIS believe that the level of importance for each of the social skills highly depend on the setting where the student is situated. That is why students, parents and teachers rate the social skills of the student in SSIS to give a broad picture of the child's behaviour in various settings and from different perspectives. However, although parent's and teacher's ratings are strongly recommended to be done, it is not compulsory. Scoring is easy and can be interpreted straight forward by means of interpretive tools. Updated and representative norms as well as improved psychometric properties are available to give accurate results. Norms are sex-specific, age-based and different for students, parents and teachers.

SSIS measures three main variables: social skills, problem behaviour and Autism spectrum. There are seven sub-variables for social skills and four sub-variables for problem behaviours. Autism spectrum does not have any sub-variables. A list of variables and sub-variables can be found inTable 7.

The test was translated to Farsi in order to be used by Iranian participants and their parents. The next step was normalizing the test which was done by 30 Iranian psychologists. The psychologists reviewed the test in sequence and compared it to the original English version to make sure the translation is accurate and the translated words are appropriate for our target age group. Moreover, we used parent and student versions of SSIS.

Table 7: Variables of the SSIS rating scale

Variables	Sub-Variables
Social Skills	Communication Cooperation Assertion Responsibility Empathy Engagement Self-Control
Problem Behaviour	Externalizing Bullying Hyperactivity/Inattention Internalizing
Autism Spectrum	No sub variables

5. Results

In this chapter, we report the results from the study. Demographic data of the participants was acquired and analysed to get a general overview of the participants. Other results of our study have been obtained from two different assessments methods: the standard SSIS psychological test (discussed in detail in Chapter 3), and from analysing interaction data.

The SSIS test measures social skills and problem behaviour. We extracted four variables from SSIS: Social Skills of the student on the Child questionnaire (SSC), Social Skills of the student on the Parent questionnaire (SSP), Problem Behaviour of the student on the Child questionnaire (PBC) and finally Problem Behaviour of the student on the Parent questionnaire (PBP).

Furthermore, we analysed data extracted from participants' interactions with the system. For the first phase of the study, we report the number of attempted and solved problems and the interaction time for each session. In the second phase, we measured the same variables as in the first phase except for the number of attempted problems. That is because due to a technical error we were not able to extract the relevantdata.For the third phase, we report the number of options the child wrote down on the worksheet and also the ability of solving problems according to the written options.

5.1 Analysis of Demographic Data

Sixty seven children aged 8 to 12 participated in our study. Seven children chose not to complete the experiment. Therefore, we removed them from the study and analysed the data as per protocol (discussed in Chapter 4). As a result, we ended up with 60 children who completed the experiment. There were 20 children in each of the three groups (ADHD-Com group, NOADHD group and ADHD-Psy group). All of the participants were of the same ethnicity. Table 8 presents the summary of the demographic data. The average age of the participants was 10.15 for the ADHD-Com group, 9.59 for the NOADHD group, and 9.82 for the ADHD-Psy group. A comparison on the age of participants was conducted using ANOVA. There was no significant difference on age between the three groups. Also, there were 14 males in the ADHD-Com group, 10 males in the NOADHD group, and 12 males in the ADHD-Psy group. Again, we analysed the results of a comparison on the sex of the participants by a Chi square analysis given that it is a dichotomous variable. As a result, there was no significant difference on the sex of participants between the three groups. Data analysis was also done on the educational state of the parents of the participants to obtain a general view about the family. The educational states were classified into five categories including: primary school, intermediate school, high school diploma or associate degree, bachelor degree, and Master's or PhD degree. There was no significant difference between the three groups on the parent's education.

Table 8: Demographic data

Characteristic		ADHD-Com n=20	NOADHD n=20	ADHD-Psy n=20
Age, years: mean (s.d.)		10.15 (0.83)	9.59 (0.87)	9.82 (1.05)
Male, n (%)		14 (70)	10 (50)	12 (60)
Education of mother n (%)	**Primary school**	3 (15)	3 (15)	2 (10)
	Intermediate school	2 (10)	2 (10)	3 (15)
	High school diploma / Associate degree	7 (35)	8 (40)	11 (55)
	Bachelor degree	7 (35)	5 (25)	4 (20)
	Master/PhD degree	1 (5)	2 (10)	0 (0)
Education of father n (%)	**Primary school**	2 (10)	3 (15)	2 (10)
	Intermediate school	3 (15)	6 (30)	7 (35)
	High school diploma / Associate degree	9 (45)	5 (25)	7 (35)
	Bachelor degree	4 (20)	3 (15)	4 (20)
	Master/PhD degree	2 (10)	3 (15)	0 (0)

5.2 Comparison of the SSIS Scores within Groups

Student's improvement on social skills and problem behaviours on both parent questionnaire and child questionnaire were measured by t-test on SSC, SSP, PBC and PBP.

We compared the standard score of each variable on the pre-test to the standard score of the same variable on the post-test. Table 9 presents the results.

Table 9: Results for students' improvement
(represents significant results, and * marginally significant results)**

	ADHD-Com	NOADHD	ADHD-Psy
SSC pre-test	86.25 (16.68)	92.55 (15.67)	80.45 (15.94)
SSC post-test	96.20 (10.29)	99.50 (11.61)	82.95 (12.96)
Improvement on SSC	t=3.16, $p<0.01$**	t=2.19, $p<0.05$**	NS
SSP pre-test	74.7 (19.70)	88.85 (16.64)	68.5 (13.01)
SSP post-test	78.7 (19.29)	96.3 (18.16)	74.4 (17.13)
Improvement on SSP	NS	t=2.38, $p<0.05$**	t=1.51, p=0.07*
PBC pre-test	115.1 (14.95)	100 (12.66)	117.8 (18.84)
PBC post-test	104.75 (11.74)	98.55 (14.08)	116.2 (20.39)
Improvement on PBC	t=4.42, $p<0.001$**	NS	NS
PBP pre-test	130.45 (12.39)	117.4 (16.66)	130.95 (23.49)
PBP post-test	128.85 (6.97)	105.9 (15.07)	129.2 (22.42)
Improvement on PBP	NS	t=3.99, $p<0.001$**	NS
Autism pre-test	19.4 (5.43)	15.1 (6.14)	20.5 (5.59)
Autism post-test	18.95 (9.00)	12.05 (6.02)	18.8 (7.13)
Improvement on Autism	NS	t=2.52, $p<0.05$**	t=1.38, p=0.09*

As can be seen inTable 9, our system improved social skills and problem behaviours of students in the ADHD-Com group significantly based on the child questionnaire. After working with our system,the children without ADHD improved in all areas except for the Problem Behaviour on the Child questionnaire (PBC). On the other hand, the ADHD-Psy group marginally improved on Social Skills on the Child questionnaire (SSC) and also on the Autism variable.

According to these results, the children's improvement differs in child questionnaire compared to the parent questionnaire. For instance, in the ADHD-com group children improved significantly on both social skills and problem behaviourbased on the child questionnaire, but not in the parent questionnaire. That means our intervention worked well according to the child's point of view but not parents'. It may be because our system works on the children's mind set. So that instead of looking at a social problem as a barrier that aims to hurt them, they see the social problem as a challenge that is there to be solved by them. As this change in more internal to the child, parents are not able to see its impact on their children in short period of time. Another reason can be as a result of conducting the post-test immediately at the last session of intervention. As a result parents were not given a chance to see their children's new mind set in action. The parents rated the group intervention (ADHD-Psy) better. It may have happened because in that condition children worked as a group and while they were receiving the intervention; their parents were sitting together in the waiting area and talking. They even could see their children practicing in the group from where they were sitting, whereas in the other two conditions children worked with the system individually. The parents were sitting in the waiting area alone. They could see their children working with the computer for 20 to 30 minutes. They may consider the session as playing with yet another computer game and do not accept it may have positive impact on the child's learning.

5.3 Comparison of the SSIS Scores across Groups

We used ANCOVA to test the differences between the group means of post-test variables on the SSIS test using the scores on the pre-test as a covariate. We analysed the differences between group means of four variables in the post-test: Social Skills of the student on the Child questionnaire (SSC), Social Skills of the student on the Parent questionnaire (SSP), Problem Behaviour of the student on the Child questionnaire (PBC) and finally Problem Behaviour of the student on the Parent questionnaire (PBP). To be able to perform ANCOVA, we need to meet nine assumptions. We tested the required assumptions for conducting ANCOVA on our main variables SSC, SSP, PBC and PBP:

Assumption 1:Our dependent variable and covariate variable were measured on a continuous scale.

Assumption 2: There was a linear relationship between pre- and post-intervention of all the variables for each intervention type, as assessed by visual inspection of the scatterplot.

Assumption 3:There were different participants in each group with no participant being in more than one group.

Assumption 4:There were no outliers in the data for SSC and PBP, as assessed by no cases with standardized residuals greater than ±3 standard deviations. However, there was an outlier in the data for SSP (ZRE=-3.14). Also there was an outlier for PBC (ZRE=3.38). We removed the outliers and performed the analysis again.

Assumption 5: Standardized residuals for the interventions and for the overall model were normally distributed, as assessed by Shapiro-Wilk's test ($p > .05$).

Assumption 6:There was homogeneity of regression slopes as the interaction term was not statistically significant (Table 10).

Table 10:Test of homogeneity of variances

	F-test	Sig
SSC	F(2,54)= 0.017	p = .984
SSP	F(2,53)= 0.314	p = .732
PBC	F(2,53)= 0.703	p = .500
PBP	F(2,54)= 0.279	p = .757

Assumption 7:At each level of the independent variable, the covariate was linearly related to the dependent variable.

Assumption 8:There was homoscedasticity and homogeneity of variances, as assessed by visual inspection of a scatterplot and Levene's test of homogeneity of variance respectively.

Assumption 9:There were not any interactions between the covariate and the independent variables.

After confirming that all nine assumptions over our targeted variables were met, we ran ANCOVA on our data. Post hoc analysis was performed with a Bonferroni adjustment on SSC, SSP, PBC and PBP to obtain pairwise comparison Table 11 shows a summary of the results from conducting ANCOVA on data.

Table 11: ANCOVA results

(represents significant results, and * marginally significant results)**

	F-test	Sig	Partial Eta squared	Significant Differences
SSC	F(2,56) = 8.102	p < 0.005**	0.224	ADHD-Com: M(SD): 96.26 (2.32) p=0.004** ADHD-Psy: M(SD): 84.98 (2.38) p=0.002** NOADHD: M(SD): 97.41 (2.38)
SSP	F(2,55) = 1.219	NS	0.042	NS
PBC	F(2,55) = 1.642	NS	0.056	NS
PBP	F(2,56) = 4.857	p <0.05**	0.148	ADHD-Com: M(SD): 126.28 (3.37) p=0.025** NOADHD: M(SD): 111.34 (3.85) p=0.025** ADHD-Psy: M(SD): 126.33 (3.74)

Conducting a comparison on SSC post-intervention using Bonferroni correction showed that the mean score for the ADHD-Com group (M=96.26, SD=2.32) was significantly higher than the ADHD-Psy group (M=84.98, SD=2.38), p=0.004. That means ADHD-Com group improved significantly more on SSC than the ADHD-Psy group. Also, the mean score on SSC for NOADHD group (M=97.41, SD=2.38) was significantly higher than the ADHD-Psy group (M=84.98, SD=2.38), p=0.002. That means that the NOADHD group improved significantly more on SSC than the ADHD-Psy group. Any comparison between ADHD-Psy group and the NOADHD group is not important to us, because in these two groups children were different (with and without ADHD) and the intervention was also different (computer-based intervention vs. group-based intervention).

Post-intervention SSP and Post-intervention PBC did not show any significant differences in between-groups comparison. Conducting a comparison on PBP post-intervention using the Bonferroni correction showed that the mean score for the NOADHD group (M=111.34, SD=3.85) was significantly lower than the ADHD-Com group (M=126.28, SD=3.73), p=0.025. That means NOADHD group improved significantly more on PBP than the ADHD-Com group. Here we are measuring problem behaviour,so the smaller average represents a better result. Also the mean score on PBP for NOADHD group (M=111.34, SD=3.85) was significantly lower than the ADHD-Psy group (M=126.33, SD=3.74), p=0.025. That means NOADHD group improved significantly more on PBP compared to the ADHD-Psy group. Although we expected the children without ADHD to get better results compared to the children with ADHD, significant improvement in problem behaviour of children without ADHD from parents' point of view shows our system has been effective so that parents have been able to see a big difference in their children's problem behaviour even in short period of time compared to children with ADHD.

5.4 Analysing the Interaction Data

We analysed screen captures of each session to measure children's performance while working with the system. We measured the following attributes for each session: the session length, number of solved problems, number of attempted problems and completion rate. Due to a technical problem, the screen captures for the second phase including sessions 4-6 were not recorded properly for some participants. Therefore, we cannot report the number of attempted problems in phase two. However, the number of stars (solved problems) and the session length was recorded properly for all sessions of all participants.

Table 12: Performance data (all sessions)

(represents significant results, and * marginally significant results)**

Item	ADHD-Com	NOADHD	p
Session length (min)	24.55 (1.82)	25.18 (1.21)	NS
Solved problems	10.52 (3.01)	11.81 (3.01)	NS
Completion rate (%)	80.87 (11.31)	88.22 (8.5)	t=2.58, p<0.05**
Session 1 - solved problems	4.45 (2.63)	6.8 (3.98)	t=2.20, p<0.05**
Session 2 - solved problems	9.85 (4.37)	12.55 (5.32)	t=1.75, p=0.09*
Session 3- solved problems	13.25 (6.64)	15.1 (5.37)	NS
Session 4 - solved problems	9.6 (5.18)	9.9 (4.76)	NS
Session 5 - solved problems	11.35 (4.66)	13.55 (4.64)	NS
Session 6- solved problems	14.6 (5.12)	12.95 (3.71)	NS
Session1-completion rate (%)	70.96 (22.25)	80.51 (17.44)	t=1.93, p=0.06*
Session2-completion rate (%)	83.2 (10.48)	90.22 (8.44)	t=2.31, p<0.05**
Session3-completion rate (%)	88.46 (15.11)	93.93 (8.52)	NS
Session 1-attempted	6.1 (2.95)	8.25 (3.85)	t=1.98, p=0.05**
Session 2-attempted	11.5 (4.29)	13.7 (5.14)	NS
Session 3-attempted	14.25 (6.02)	15.8 (5.02)	NS
Session 1-time	24.23 (3.45)	25.68 (2.7)	NS
Session 2-time	23.68 (2.83)	24.83 (2.37)	NS
Session 3-time	24.83 (3.24)	24.99 (3.28)	NS
Session 4-time	23.97 (2.99)	25.03 (2.94)	NS
Session 5-time	25.04 (3.39)	25.58 (3.35)	NS
Session 6-time	25.56 (3.46)	25 (2.28)	NS

As indicated inTable 12,there was no significant difference between times in the two groups. That is because all participants were expected to work with the system for 20-30 minutes. There was no significant difference between the average numbers of solved problems per session for the two groups.

The participants could select problems they wanted to attempt. However, they were not allowed to repeat problems within the same session. As Table 12 presents, there was a significant difference between the average rates of completed problems of the two groups. Children without ADHD were able to complete more problems on average than ADHD children. Children without ADHD solved significantly more problems compared to the ADHD group in the first session. The difference became less in the second session (marginally different) and no significant difference from the third session onwards (Figure 30). Moreover, the children without ADHD completed significantly more problems in the second session compared to the ADHD group. However, the difference was not significant in the first and third sessions.Also children without ADHD attempted significantly more problems in the first session compared to ADHD children. However, the difference between the two groups on number of attempted problems was not significant in sessions 2 and 3. Therefore, we conclude that initially NOADHD children were more successful in phase one, but later the difference between the two groups was reduced.

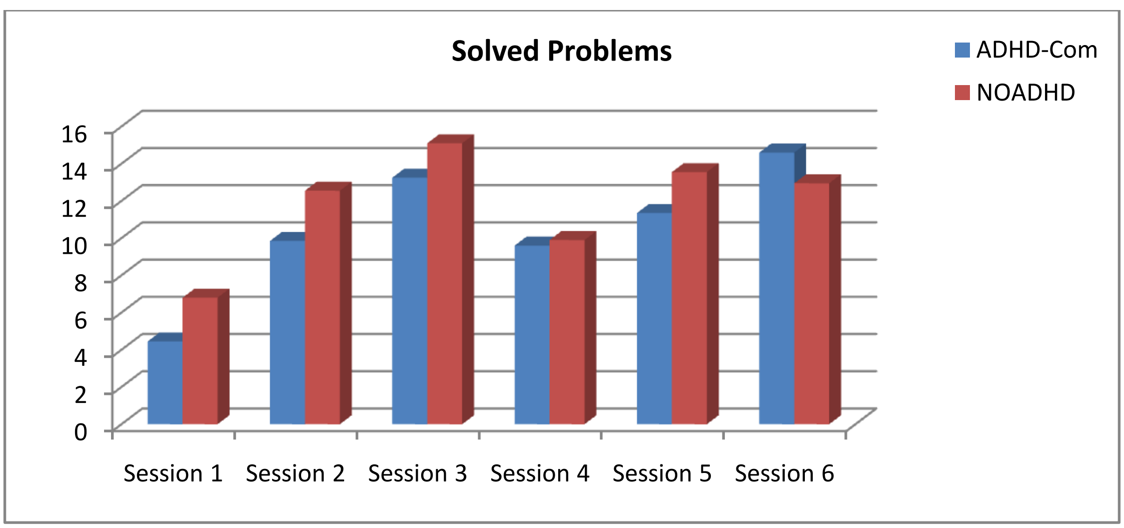


Figure 30: Number of solved problems (all sessions)

5.4.1 PERFORMANCE IN PHASE 1

We extracted and analysed the data from screen captures of the first three sessions (Phase 1) to study the performance of ADHD children compared to the children without ADHD. First of all, we focused on each group separately to measure improvement of children from the first session to the last session of the first phase (Table 13).

Table 13: Performance of ADHD and NOADHD groups

(represents significant results, and * marginally significant results)**

Item		Session 1	Session 3	p
ADHD-Com	Solved problems	4.45 (2.63)	13.3 (6.59)	p<0.001**, t=6.82
	Abandoned problems	1.65 (1.09)	0.95 (0.94)	p=0.054*, t=2.05
	Solution options per problem	2.03 (0.49)	1.61 (0.34)	p<0.05**, t=2.79
	Correct solution options (%)	41.62 (14.66)	57.84 (15.49)	p<0.01**, t=3.33
	Justification options per problem	3.24 (0.96)	2.39 (0.76)	p<0.05**, t=2.64
	Correct justification options (%)	25.03 (12.91)	41.07 (13.45)	p<0.01**, t=3.49
NOADHD	Solved problems	6.8 (3.98)	15.1 (5.37)	p<0.001**, t=7.78
	Abandoned problems	1.45 (1.10)	0.7 (0.98)	p=0.072*, t=1.89
	Solution options per problem	1.75 (0.52)	2.5 (0.64)	NS
	Correct solution options (%)	52.77 (13.75)	61.4 (12.58)	p<0.05**, t=2.43
	Justification options per problem	2.5 (0.64)	2.17 (0.45)	p=0.060*, t=1.99
	Correct justification options (%)	33.92 (10.97)	45.07 (10.5)	p<0.001**, t=4.40

We measured the number of solved and abandoned problems, the number of solution options per attempted problem, the number of justification options per attempted problem, and also the percentage of correctness of the solution options and justification options for each session. As indicated inTable 13, both groups solved significantly more problems in session 3 compared to session 1. Also, both groups abandoned marginally less problems in session 3 compared to session 1. Children in the ADHD group selected significantly less solution options per attempted problem. However, there was no significant difference between the number of solution options per attempted problems in sessions 1 and 3 for the NOADHD group. Moreover, the number of justification options per attempted problems was significantly lower in the third session compared to the first session for the ADHD participants. However, children without ADHD had marginally significantly less justification options per attempted problems in the third session compared to the first session. Moreover, the correctness of the chosen solution options and justification options were significantly higher in session 3 compared to session1 for both groups. However, the number of abandoned problems was marginally less in session 3 compared to session 1 in both groups.

After comparing the performance in the first session to the third session for each group, we looked at a comparison of the two groups session by session (Table 14-16). As indicated in Table 14, in session 1, children without ADHD solved significantly more problems compared to ADHD children. Moreover, compared to the children without ADHD, the number of solution options per attempted problems was marginally higher and the number of justification options per attempted problems was significantly higher in the ADHD children. Also, the percentage of correct solution options and justification options were significantly higher in children without ADHD compared to ADHD children. However, the number of abandoned problems, the number of solution options, and the number of justification options were not significantly different between the two groups.

Table 14: Performance of ADHD and NOADHD groups (session 1)

(represents significant results, and * marginally significant results)**

Item	ADHD-Com	NOADHD	p
Solved problems	4.45 (2.63)	6.8 (3.98)	p<0.05**, t=2.20
Abandoned problems	1.65 (1.09)	1.45 (1.1)	NS
Solution options per problem	2.03 (0.49)	1.75 (0.52)	p=0.08*, t=1.74
Correct solution options (%)	41.62 (14.66)	52.77 (13.75)	p<0.05**, t=2.46
Justification options per problem	3.24 (0.96)	2.5 (0.64)	p<0.01**, t=2.84
Correct justification options (%)	24.68 (12.91)	33.92 (10.97)	p<0.05**, t=2.34

In session 2 (Table 15), the NOADHD group solved marginally more problems compared to ADHD children. Compared to the first session, the ADHD-Com group improved on the number of solved problems as they became closer to the children without

ADHD on this item. However, the number of solution options per attempted problems and the number of Justification options per attempted problems were larger in the ADHD group compared to the NOADHD group. Moreover, there was no difference between the numbers of abandoned problems between the two groups. The percentage of correct solution options and justification options were significantly more in children without ADHD compared to ADHD children.

Table 15: Performance of ADHD and NOADHD groups (session 2)
(represents significant results, and * marginally significant results)**

Item	ADHD-Com	NOADHD	p
Solved problems	9.85 (4.37)	12.55 (5.32)	p=0.087*, t=1.75
Abandoned problems	1.65 (0.88)	1.15 (1.09)	NS
Solution options per problem	1.89 (0.57)	1.5 (0.27)	p<0.05**, t=0.41
Correct solution options (%)	49.89 (14.03)	64.15 (12.08)	p<0.01**, t=3.44
Justification options per problem	2.82 (0.79)	2.11 (0.52)	p<0.01**, t=3.34
Correct justification options (%)	32.07 (8.66)	45.47 (13.36)	p<0.001**, t=3.76

As indicated in Table 16, in session 3 there was no significant difference between ADHD children and children without ADHD on any of the measured items. By looking at performance of children, it can be observed that although at the beginning of phase one ADHD children had lower performance than children without ADHD, at the end of this phase they caught up and showed the same performance.

Table 16: Performance of ADHD and NOADHD groups (session 3)
(represents significant results, and * marginally significant results)**

Item	ADHD-Com	NOADHD	p
Solved problems	13.3 (5.37)	15.1 (5.37)	NS
Abandoned problems	0.95 (0.98)	0.7 (0.98)	NS
Solution options per problem	1.61 (0.34)	1.59 (0.31)	NS
Correct solution options (%)	57.84 (15.49)	61.4 (12.58)	NS
Justification options per problem	2.39 (0.76)	2.17 (0.45)	NS
Correct justification options (%)	41.07 (10.5)	45.07 (10.5)	NS

Performance of children in the first three sessions (phase1) is summarized in Table 17. The NOADHD group solved significantly more problems in phase 1 compared to ADHD children. However, there was no significant difference on the number of abandoned problems between the two groups. Also ADHD children selected significantly more solution options per attempted problems than children without ADHD. Furthermore, the number of justification options per attempted problems was significantly larger for ADHD children compared to the children without ADHD. On the other hand, the percentages of both correct solution options and correct justification options were significantly higher in children without ADHD compared to ADHD children.

Table 17: Performance of children in phase 1, averages per session

(represents significant results, and * marginally significant results)**

Item	ADHD-Com	NOADHD	p
Solved problems	9.29 (5.99)	11.48 (5.98)	p<0.05**, t=2.09
Abandoned problems	1.42 (1.01)	1.26 (1.06)	NS
Solution options per problem	1.82 (0.51)	1.73 (0.46)	p<0.01**, t=2.79
Correct solution options (%)	50.91 (17.02)	59.44 (13.52)	p<0.01**, t=3.03
Justification options per problem	2.81 (0.9)	2.54 (0.79)	p<0.001**, t=4.04
Correct justification options (%)	32.72 (13.41)	41.49 (12.68)	p<0.001**, t=3.67

Selecting fewer solution and justification options is an indicator of better understanding. As seen in Figure 31, both groups selected fewer solution options per problem in session 2 compared to the first session. However, the ADHD-Com group selected fewer solution options in the third session compared to the second session, but the NOADHD group selected a slightly higher number of solution options in session 3 compared to the second session. Therefore, the ADHD-Com group improved between sessions. On the other hand, although the performance of the children without ADHD in session 3 was worse than the second session, their overall performance in phase 1 has improved as their performance in the third session is better than the first session.

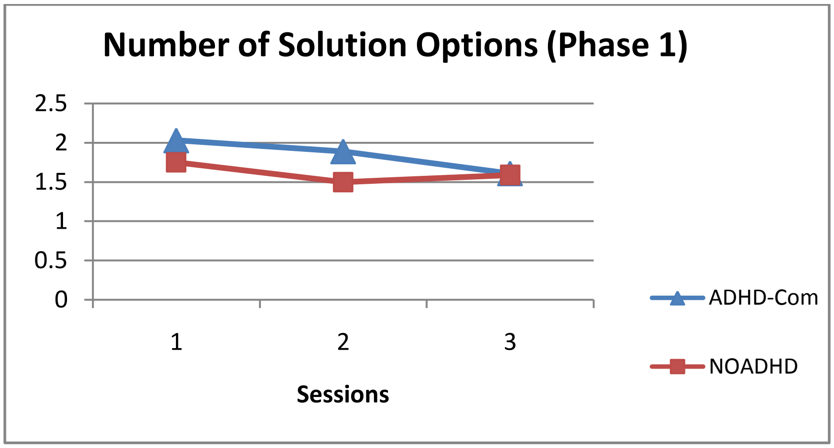


Figure 31: The number of solution options in phase 1

Figure 32 illustrates the number of justification options in phase 1. As seen in the figure, both groups selected fewer justification options per problem in session 2 compared to the first session. The ADHD-Com group selected fewer justification options in the third session compared to the second session, but the NOADHD group selected a slightly higher number of justification options in session 3 compared to the second session. As a result, the ADHD-Com group improved between sessions.

On the other hand, although the performance of the children without ADHD in the third session was worse than the second session, the performance of both groups improved on the number of justification options per attempted problem in phase 1. As seen in Figure 32, although ADHD children performed worse than children without ADHD at session 1, they caught up with them in session 3.

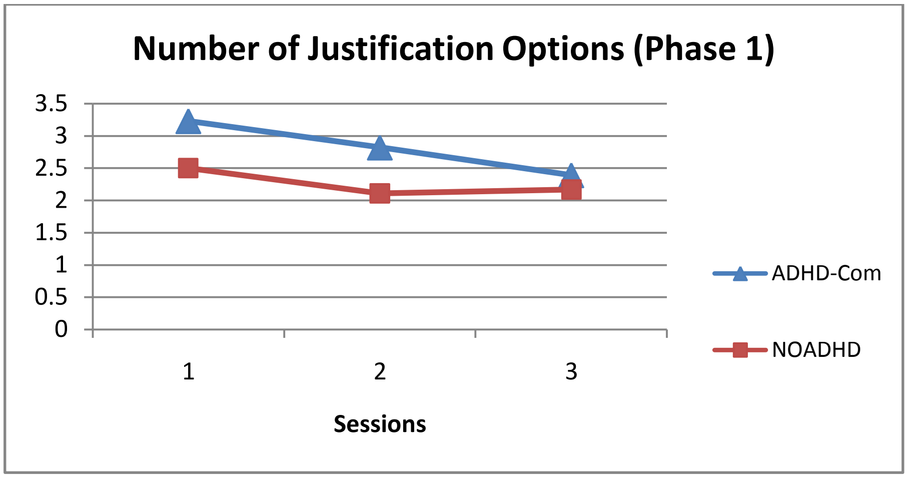
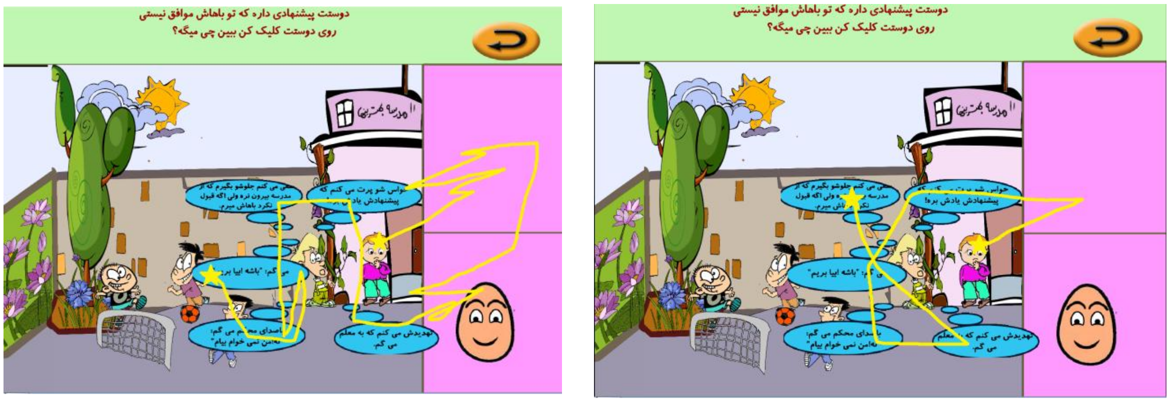


Figure 32:Number of justification options (phase1)

5.4.2 ANALYSING PATTERNS OF IMPULSIVITY

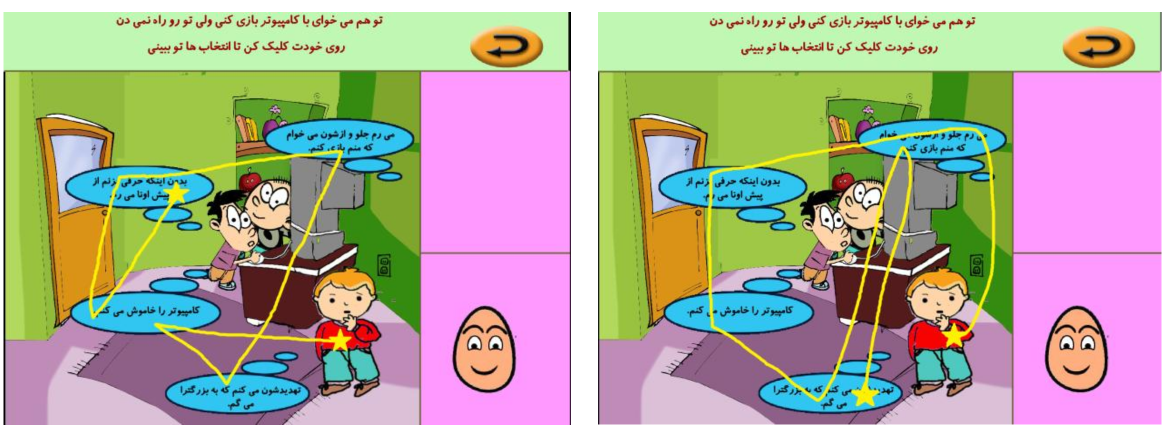
In analysing the screen captures, we discovered different patterns of mouse movements for ADHD children compared to children without ADHD. Figure 33 presents one of the problems in the system. The left part of this figure presents the mouse movements and clicks performed by a child from the ADHD-Com group, while the screenshot on the right shows the behaviour of a participant from the NOADHD group. The scenario is about making hard decisions in the school yard. After presenting the problem text, the children were expected to click on the animated character presenting themselves (the child with the pink shirt) in order to see the solution options (the blue clouds). After that, they needed to read the solution options and select the correct one. In the situation illustrated in Figure 33, both children selected an incorrect solution option. As illustrated in Figure 33(a), the ADHD child performs many aimless moves outside the solution options' region. Conversely, the child without ADHD seems to move the mouse in order to read the solution options: all the movements are around the solution options. Studying the behaviour of the same ADHD-Comparticipant in other scenarios, we found the same behaviour in all problems s/he attempted in the first session. Moreover, the behaviour of the child without ADHD also remained consistent throughout the first session.



(a) ADHD-Com participant (b) NOADHD participant

Figure 33: Patterns of impulsivity (Session 1)

We studied the pattern of mouse movement between the clicks of the same two participants on a different scenario in session 3. The scenario was joining a group in a friend’s house, wherein both children again selected the wrong solution options. As seen in Figure 34, the ADHD-Com child has moved the mouse around the solution options between the two clicks. The pattern was consistent for the other scenarios in the third session for this participant. On the other hand, the child without ADHD behaved similar to the first session.



(a) ADHD-Com participant (b) NOADHD participant

Figure 34: Patterns of impulsivity (Session 3)

5.4.3 PERFORMANCE IN PHASE 3

Phase three was paper-based, meaning the children did not work with the system. The participants were expected to complete the given worksheet by defining a problem, identifying up to four solution options and solving the problem. Phase 3 was conducted in sessions 7 and 8. Therefore, each child had two identical worksheets to do. At the end of session 6, the supervisor gave the first worksheet to children and explained how to complete the worksheet. The children were expected to complete the worksheet before attending the next session. At the beginning of session 7, the supervisor discussed the problem/solution that children had defined. However, the children could not change their solution during the discussion. The reason for the discussion was to encourage the children to justify their choices and also to make sure they have understood the process of social problem solving. At the end of the session 7, the supervisor gave the second worksheet to the child and explained that the expectations were similar to the first worksheet. The children had to bring the second worksheet to the session 8. In contrast to the first worksheet, there was no discussion about their solution (an explanation of phase 3 as well as the content of the worksheets has been covered in Chapter 3).

Each child completed two worksheets, and as a result children defined 80 problems altogether (problems are provided as Appendix D). We categorized their problems into four main categories: family issues, personal issues, problems at school, and problems with peers. Although some problems could be placed under more than one category, we tried to put the problems in the most appropriate category possible. As a result, out of those 80 problems, 23 were family problems, 20 were personal problems, 22 were problems happened during the school time, and 15 were problems with peers (Table 18).

Table 18: Category of problems (phase 3)

Problem Category	Number of problems
Family	23
Personal	20
School	22
Peers	15

Here are some example problems from each category:

Family: *"My mother did not buy me the toy that I chose in the store"; "My father deleted my favourite game in the computer"; "When my father was watching football match on TV I wanted to watch my favourite TV series"; "I had conflict with my mother when I wanted to choose what to wear"*

Personal: *"I do not like my little sister"; "I got a headache when I was at my friend's party"; "Sometimes, I wake up at midnight and cannot go back to sleep again"; "Yesterday I fall of the swing and was not sure what to do"*

School: *"The topic for essay writing was difficult and I could not write anything"; "Today in the morning I just realized that I forgot to study Farsi"; "I'm scared when the teacher wants me to answer a question"; "I lost my book today and my name was not written on the book, I had no idea how to find it again"*

Peers: *"One of group mates did not let us to do anything and wanted to do everything by him"; "I forgot to take my homework note book to school"; "I did not well in my exam and my teacher said my mark out loud and I got upset"; "I had a conflict with my friend in the school bus"*

As seen from Table 19, the participants from the two groups suggested similar number of solution options on average. Moreover, both groups defined the same number of options when trying to solve their problems. The difference for the number of chosen options is also not significant.

Table 19: Performance of ADHD and NOADHD groups (phase 3)

Item	ADHD	NOADHD	p
No of solution options	3.58 (0.72)	3.6 (0.63)	NS
No of chosen options	1.4 (0.71)	1.55 (0.9)	NS

In addition to studying the success rate of solving problems in total, we looked at the success rate of solving problems in sessions 7 and 8. This comparison is interesting because the problems children specified in session 7 were discussed with the supervisor, while there was no discussion in session 8.

Table 20: Percentage of solved problems

	ADHD-Com	NOADHD	p
Average	82.5%	90%	NS
Worksheet 1	70%	80%	NS
Worksheet 2	90%	100%	NS

The ADHD-Com group solved 33 problems out of 40 (82.5%), compared to the NOADHD group who solved 36 problems out of 40 (90%). Looking at the first and the second worksheets separately, it can be seen that fourteen children from the ADHD-Com group solved their problems successfully(70%). However, 16 NOADHD participants were able to solve their problems (80%). For the second worksheet there was only one ADHD child who could not solve his/her problem (success rate=90%). Also all children without ADHD managed to solve their problems in the second worksheet (success rate=100%). However, a comparison between the two groups on the performance of the participants showed no significant differences. That means both groups performed similarly in phase three (Figure 35).

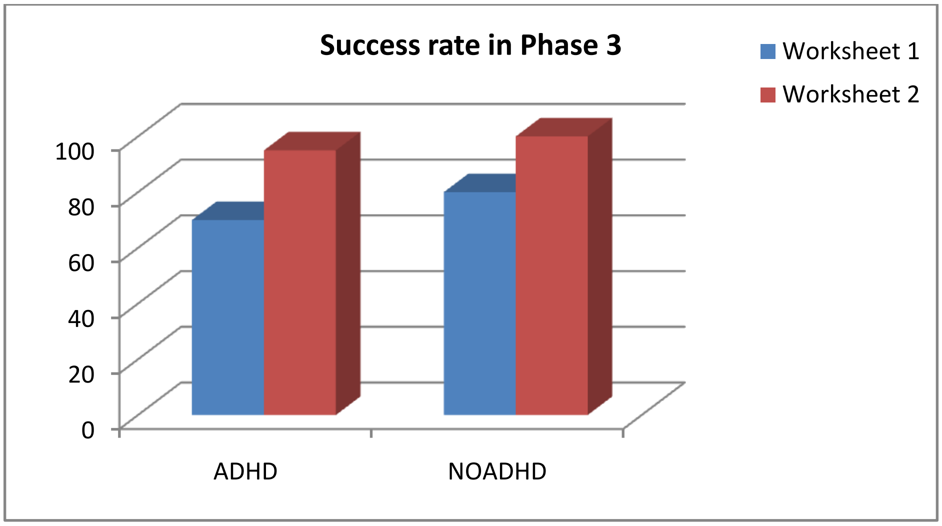


Figure 35: Success rate of solving problems in phase 3

5.5 Analysing Problems

We had 20 problems in our system. Table 4and 5 in Chapter 3 present a description of the problems. There were 8 problems wherein solution options were animated human characters: P1, P2, P6, P7, P11, P12, P16, and P17. However, solution options were presented as the child's thoughts in other problems. There were 4 solution options for all the problems in this latter category except for P3 with 5 solution options and P4 with 6 solution options.

We studied the problems when they were first attempted by the children and analysedhow many were abandoned on the first attempt. Table 21 summarizes the results, which show that all seven problems that have never been abandoned have human characters as solution options.These problems are easier to solve as the users does not need to read any text for the solution options. However, the justification options are in the form of on-screen texts. The only problem of this type that abandoned twice was P2 (offering help in school yard). The highest rate of abandonments was for P4, P13, P3, and P8. We can argue that the reason P3 and P4 were abandoned a lot was because they had larger number of solution options compared to the rest of the problems in their category. Moreover, from the problems with the higher rate of abandonments, P3, P8, P13, and P18 were all about making hard decisions in various social contexts: school yard, store, classroom, and friend's house. It can be concluded that making hard decisions has been the hardest social skill to practice for the children.

However, the high rate of abandonment for P10 (resolving conflict in store) can be because of the ambiguity in the justification options. The problem definition is the friend suggests stealing a CD from the store. The correct solution option is to say:" No, I do not want to do this". There are three justification options for this solution options: (a) that is my right to say no to the wrong suggestions, (b) the store has a camera and we can be seen, (c) I have many computer games at home. The correct justification option is "a", however, "b" was selected by children as yet another rational justification to the solution option.

Table 21: Abandonment rate in problems

Problem number	Solved	Abandoned	Abandonment Rate
P1	40	0	0 %
P2	37	2	5.41 %
P3	26	13	50 %
P4	28	12	42.86 %
P5	31	7	22.58 %
P6	39	0	0 %
P7	34	0	0 %
P8	21	13	61.9 %
P9	27	7	25.93 %
P10	24	8	33.33 %
P11	34	0	0 %
P12	29	0	0 %
P13	23	11	47.83 %
P14	25	7	28 %
P15	22	6	27.27 %
P16	36	0	0 %
P17	31	0	0 %
P18	26	8	30.77 %
P19	28	4	14.29 %
P20	30	1	3.33 %

5.6 Concluding Comments

We discussed the results of our study in this chapter. The findings of our study show the positive impact of our intervention on children's social skills, problem behaviour, and performance. Analysing the data from a parallel psychotherapist-directed intervention showed our intervention improved ADHD children's social skills and problem behaviours significantly more than the parallel intervention. Moreover, our system enabled ADHD children to reach the same level of performance as children without ADHD.

We also discovered impulsivity patterns by analysing the screen captures of participants and how the patterns were improved as a result of working with our system. Furthermore, we obtained a general idea about designing animated social problems for ADHD children.

6. Discussion and Future Work

Learning is a challenge for ADHD children due to their inattentiveness, impulsivity, and hyperactivity. The problem gets highlighted in traditional contexts where the ADHD child needs to sit still and listen to the teacher. New approaches need to be developed in designing educational contexts for ADHD children as well as adapting the teaching approaches to fit these children's special needs.

6.1 Summary and Research Objectives

The research presented in this thesis addressed the following research objectives: (1) to develop a simulation game in order to teach social-problem solving skills to ADHD children, (2) to explore the effectiveness of teaching social problem-solving skills to ADHD children by simulation games compared to a psychotherapist-directed intervention, (3) to assess whether our game enables ADHD children to transfer what they learnt in the game into the real life situations, (4) to study learning achievement as well as the ability of solving social problems of ADHD children compared to children without ADHD as a result of working with TARLAN.

In order to reach the first objective, we designed and developed a simulation game (TARLAN)with three phases (from elementary to advanced). TARLAN encompasses of 20 animated problems that cover 4 social contexts as well as 5 social skills. The animated scenarios were designed according to the ADHD participant's everyday life and culturewherein children can practise solving social problems.

The second objective was reached by conducting an experiment in which three groups of children were allocated to two interventions: a computer-based intervention in which children worked with TARLAN and a psychotherapist-directed intervention in which children worked with a known psychological approach. Children with ADHD were randomly allocated to the interventions. We also had a control group in which children without ADHD also worked with TARLAN. We recorded screen captures of children while interacting with the system. Analysing the interaction data of the first 3 sessions (phase 1) showed even though ADHD children's performance was below the performance of the children without ADHD in the first session, they caught up in the last session (no significant difference on any of the measured variables).

The best way toreach the third objective of the research was to observe our participants in their everyday life, which was expensive. Therefore, we designed phase 3 of TARLAN with the purpose of simulating transfer. In phase 3 we asked children to do an activity of their own. Analysing the data in phase 3 showed the children (with and without ADHD) could apply their knowledge learnt about social problem-solving skills from TARLAN in solving their self-defined problems.

In order to reach the fourth objective, the Social Skills Improvement System (SSIS) was used as pre- and post-tests to assess social skills acquisition as well as problem behaviour of ADHD children (within group) and also in comparison with the parallel psychotherapist-directed and control group (across groups). The results of SSIS test showed our game improved children's social skills as well as problem behaviour significantly more not only within groups but also across groups.

6.2 Research Contributions

The results of this thesis contributed to an intersection of different disciplines: education, psychology and computer science. The main contribution of this study is to illustrate the positive impact of serious games in improving social problem-solving skill of children with ADHD. Our simulation game (TARLAN) acts as an effective intervention that applies SOCCSS as its instructional strategy and has been designed and developed according to ADHD children's special needs. TARLAN helps ADHD children to learn social problem-solving skill in an attractive way in which paying attention to the learning materials is not challenging. Children can practise social problem-solving skills without being worried about the consequences of making mistakes. This game can be used by teachers, psychologists and care-givers as an effective tool as it is available to the ADHD children anytime they wish. Using TARLAN can save the time and money that the care-givers spend on expensive psychotherapist-directed training. The game can be used by the large number of users at the same time. TARLAN can be replaced by the traditional approaches led by psychologists as our study showed its positive impact on social skills and problem behaviour of children compared to the psychological approaches.

The fact that TARLAN enables the ADHD children to transfer what they learn to the real life is an important achievement of our study. It is mainly because the scenarios are designed based on the ADHD children's everyday life and culture. Our study showed that although performance of the ADHD children was poor at the beginning of the experiment, they caught up with children without ADHD as a result of working with TARLAN.

Unlike previous studies in the computer science, we used the SSIS test as our external assessment tool which is the most recent and precise tool to measure social skills.

6.3 Limitations of work

This project was an integration of computer science and psychology; meaning that as computer scientists we needed to work closely with psychologists in order to make sure that we meet the psychological requirements of the ADHD children in designing the system. Working in between these two disciplines arose some conflicts, especially in the different ways of reporting the results of the study.

On the other hand, the project was done at the University of Canterbury whereas the experiment was conducted in Iran. Keeping the team together in two different countries as well as two different disciplines required a lot of time and energy.

Parents found it hard to bring their children to take part in our study. The main reasons were: The study had to be done during the school period, the participants had to attend 8 sessions in order to complete the interventions, the place of study was in the city centre, and was winter in Iran at the time of conducting the study. Therefore, finding 60 participants was quite challenging.

We had an immediate post-test but itwas not possible to have a delayed post-test to test whether children retained their improvements or not.

The economic situation of Iran has changed since two decades ago. The main earner person in the family may have two or three jobs. Therefore, there is no Iranian socioeconomic index as a reference available to researchers of behavioural sciences or psychology. As a result, although we had the occupation of the main earner's occupation of our participants, we could not obtain any socio-economic information about them.

Our external assessment tool (SSIS) has three different versions: children, parents, and teachers. We did not have access to the teachers of our participants; therefore we did not do the teacher's version.

6.4 Future Directions

While the results of this study revealed many interesting and novel findings regarding the effectiveness of applying simulation games to teaching social skills to ADHD children, many questions remain unanswered. For example: can simulation games be used to teach other learning materials, such as science, to the ADHD children? Do simulation games have a similar positive impact on children with other disabilities, such as Asperger or autism? Will we get similar results from teaching other social skills with the aid of simulation games?

Conducting this research also lightened up some ideas for future work:

- Our system provides one animated problem for each social problem per social context. Adding more problems for each social skill per social context makes the system more comprehensive and less repetitive.
- In order to make the results of our study stronger, it would be desirable to use the SSIS assessment of teachers.
- Instead of placing a self-avatar in the animated problems that helps the child to see himself/herself in the animated scenario, the scenario can be designed from the view point of the user's eyes, so that the user can move virtually through the environment and interact with the different objects in the virtual environment.
- The results of this study can open another field of research where simulation games are designed for ADHD adults with social skills deficit.

- Developing standard guidelines for designing educational software for ADHD children would be helpful in order to customize the software environments to meet the ADHD users' special requirements.
- SSIS Rating Scale is a comprehensive tool in which different sub-variables are rated for social skills and problem behaviour. As a result, we have a handful of untouched data that can be analysed in order to obtain detailed results.
- TARLAN is only applicable to Farsi-speaking children. Converting the system to Englishis one of our major future plans, in order for TARLAN to be understandable for a wider population and also can be customized according to the requirements of users in different countries easier.

Appendix A: The Human Ethics Approval

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

HUMAN ETHICS COMMITTEE

Secretary, Lynda Griffioen
Email: human-ethics@canterbury.ac.nz

Ref: HEC 2014/02

17 March 2014

Atefeh Ahmadi
Department of Computer Science & Software Engineering
UNIVERSITY OF CANTERBURY

Dear Atefeh

The Human Ethics Committee advises that your research proposal "An intelligent tutoring system for ADHD children to teach social problem-solving skills" has been considered and approved.

Please note that this approval is subject to the incorporation of the amendments you have provided in your emails of 6 and 17 March 2014.

Best wishes for your project.

Yours sincerely

Lindsey MacDonald
Chair
University of Canterbury Human Ethics Committee

Appendix B: The Human Ethics Application

UNIVERSITY OF CANTERBURY
HUMAN ETHICS COMMITTEE
APPLICATION FOR REVIEW & APPROVAL

This form should be completed in the light of the Principles and Guidelines issued by the Human Ethics Committee. Applicants must read those before filling out the application form. The latest versions of both the Guidelines and the Application Form can be found on the website of the Human Ethics Committee.
Website: http://www.canterbury.ac.nz/humanethics

This application form is to be used for Applications *NOT* covered by the Educational Research Human Ethics Committee (ERHEC)

Please submit **TWO hard copies**and**ONE electronic copy**ofthe completed application duly signed by applicant and supervisor or Head of Department, and all relevant documents referred to in questions 3, 7, 8, 9, 10, 11, 15 (i.e. authorizations, approvals, information and consent forms). Hard copies should be sent to the Secretary, Human Ethics Committee, Oeuvre House and electronic copies to human-ethics@canterbury.ac.nz.
Please note that it is preferred the electronic copy to be one document signed, scanned and forwarded to the Secretary of the Human Ethics Committee.

1. PROJECT NAME: An Intelligent Tutoring System for ADHD Children to Teach Social Problem-Solving Skills

2.NAME OF APPLICANT: Atefeh Ahmadi Olounabadi

Contact Telephone No: 0064 278676488, 0098 9131860614

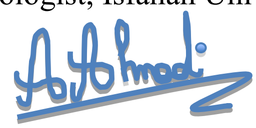
UNIVERSITY DEPARTMENT (or other contact address):Dept of Computer Science and Software Engineering

EMAIL ADDRESS: atefeh.ahmadi@pg.canterbury.ac.nz

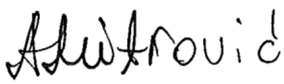
STATUS OF PROJECT: Ph.D research study

NAME OF SUPERVISOR:Prof.TanjaMitrovic

OTHER INVESTIGATORS: Assoc. Prof. Julia Rucklidge (Canterbury), Dr BadroddinNajmi, Clinical psychologist, Isfahan University of Medical Science, Iran

SIGNED BY: Applicant:  Date: 3 March 2014

HOD/Supervisor:



The checklist on the following page must be completed and signed by the applicant and, if the applicant is a student, by the applicant's supervisor

CHECK LIST

Please check the following items before sending the completed form to the Committee.

All the necessary signatures on page 1 have been obtained. **[ ]**

All the necessary approvals under Question 3 have been obtained or are

The subject of correspondence of which copies are attached. **NA**

A copy of any questionnaire, with an appropriate rubric at the beginning

or accompanied by an appropriate covering page, is attached. **NA**

A list of interview topics and, for a structured interview, a detailed list

of questions, is attached. **NA**

A copy of any advertisement, or notice, or informative letter asking

for volunteers is attached. **[√]**

A copy of each information sheet required is attached. **[√]**

A copy of each consent form required is attached. **[√]**

A copy of the required debriefing sheet is attached. **NA**

An electronic copy of the signed application has been forwarded to the HEC **[√]**

Attention to the preceding check list is intended to ensure that the application and its documentation have been thoroughly reviewed by the applicant and (where applicable) by the supervisor and that the preparation of the project is up to the standard expected of and by the University of Canterbury.

The signature of the applicant will be understood to imply that the applicant has designed the project and prepared the application with due regard to the Principles and Guidelines of the HEC, that all the questions in the application form have been duly answered and that the necessary documentation has been properly formulated and checked.

Signature of Applicant

The signature of the supervisor will be understood to imply in addition that, in the judgment of the supervisor, the design and documentation are of a standard appropriate for a research project carried out in the name of the University of Canterbury or for training in such research.

Signature of Supervisor

3 (a) WILL THE PROJECT REQUIRE ETHICAL APPROVAL FROM OTHER BODIES? eg Health and Disability Ethics Committee (HDEC) **No**

If Yes, please explain how this approval has been or will be obtained, enclosing copies of relevant correspondence.

NOTE: To save time, it is recommended that in the case of HDEC applications, an application is made concurrently with the application to the UC HEC.

(b) WILL THE PROJECT REQUIRE APPROVAL FOR ACCESS TO THE PARTICIPANTS FROM OTHER INDIVIDUALS OR BODIES? **Yes**

(e.g., parents, guardians, school principals, teachers, boards, responsible authorities including employers, etc.)

If Yes, please explain how this approval has been or will be obtained, enclosing copies of relevant correspondence.

We have a consent form that should be signed by parents.

(c) WILL THE PROJECT REQUIRE MAORI CONSULTATION? **No**

If Yes, please provide evidence that consultation has occurred or, if underway, provide a copy of approval once gained.

(d) WILL THE PROJECT REQUIRE COMMUNITY CONSULTATION? **No**

If Yes, please provide evidence of appropriate consultation.

4 (a) IS THE PROJECT BEING EXTERNALLY FUNDED? **No**

If Yes, please identify the source of funds.

(b) IS THE PROJECT COMMISSIONED BY OR CARRIED OUT ON **No**

BEHALF OF AN EXTERNAL BODY?

If Yes, please identify the body andany Intellectual Property agreements. This includes ownership of data and reports arising.

(c) IS THE PROJECT TO BE PART OF THE CEISMIC DIGITAL ARCHIVE?**No**

If so, please ensure all participants are made aware of this, and have filled in the UC CEISMIC Quake Studies consent form. See www.ceismic.org.nz.

Further, please ensure that all participants are made aware of any of the above in information sheets and consent forms provided.

A. DESCRIPTION OF THE PROJECT

Answer the following questions in language which is, as far as possible, comprehensible to lay people.

5 AIM

(a) What is the objective of the project?

The goal of this project is to develop an Intelligent Tutoring System (ITS) for ADHD children aged 8 to 12, in order to teach them social problem-solving skills. The proposed software is an educational game with the goal of helping ADHD children become independent social-problem solvers via practicing in animated scenarios.

Attention Deficit Hyperactivity Disorder (ADHD) is a developmental disorder composed of different difficulties with unknown etiology. Inattention, hyperactivity and impulsivity are three symptoms of ADHD. A knowledgeable teacher knows that ensuring that the learner is focusing on the learning materials is as important as the quality of teaching. However, the main problem with ADHD children is their inability to sustain attention for more than a few minutes during learning. Some studies, such as Goldsworthy et al. (2000), argued that regardless of their inability in sustaining attention, ADHD children are able to concentrate well when *doing some specific tasks such as playing computer games. They found the reason in the attractiveness of the activity, which is engaging enough to keep the ADHD brain awake. Another main goal of is the ability of applying the learnt material in the real life, which is hardly being considered in schools.*

Amongst all the subjects an ADHD child needs to learn, social skills have a high priority. Teaching social skills to ADHD children is quite challenging. Smart parents know the fact that making a safe and enjoyable life for their children merely is not enough to make a happy future for them. Instead they have to equip their children with the required skills in order to help them survive as soon as they start socializing with others independently. Teaching these skills to children with special needs demands considerable amount of time and patience.

In this project we have integrated different methods in order to develop an approach for teaching social problem-solving skill to children as well as applying their knowledge in real life situations. Social problem-solving skill is a formulated step-by-step process, which is computerized to make it available to teachers and caregivers more conveniently. Our system presents a set of social situations to the learner, and requires them to make a decision in terms of the action to take. An example scenario is deciding how to join a group of children to play with. For each scenario, the learner will be offered several possible actions, and the learner needs to select one of the options and its justification. The system then provides feedback in three different ways: textual, auditory and emotional (via an animated pedagogical agent). The animated agent guides the learner all the way, and communicates with the child by reading the sentences.

(b) Describe the type of information sought.

The proposed study will investigate how the social problem-solving skills *of ADHD children are affected by interactions with animated computer games. We will record information about the participants' social problem-solving skills before and after the intervention (by administering the SSIS test). We will also record information about the actions the participants take while completing tasks in the computer game.*

(c) Give the specific hypothesis, if any, to be tested.

The hypothesis is that ADHD children will improve their social skills by using animated computer games more than by being involved in a group-based psychological treatment. The social skills of participants will be measured before and after the intervention (the SSIS test), and the improvement will be determined by comparing the scores on those tests. The Social Skills Improvement System (SSIS) test is a standardized, validated test for assessing social skills, available from Pearson:

http://www.pearsonclinical.com/education/products/100000322/social-skills-improvement-system-ssis-rating-scales.html

6 PROCEDURE

Describe in practical terms how the participants will be treated, what tasks they will be asked to perform, etc. Indicate how much time is likely to be involved in carrying out the various tasks.

The study will be conducted in Iran. Sixty children aged 8 to 12 will be recruited. Forty participants will be children with ADHD, and the remaining 20 will be children without ADHD. Participants will be selected by Dr.Najmi (the associate supervisor), who will inform his colleagues working in other clinics about our study and ask them to introduce patients who match our criteria. The main advantage of this process is that all participants will already be registered in psychological clinics and have been diagnosed as having or not having ADHD.

The study includes a pre-test, followed by the intervention and a post-test. SSIS (Social Skills Improvement Scale) will be used as pre/post-test, and will be administered by Dr Najmi. The ADHD children will be divided into two groups. One group will be put under psychological intervention led by Dr Najmi, which involves group meetings. The other 20 ADHD children will work with our animated educational game. The remaining twenty children without ADHD (the control group) will be working with our system also. The study will be conducted at the NasimBamdad Clinic. All sessions, including the group meetings, will be conducted at the same place.

The study will consists of 8 sessions (two sessions per week), for the computer-based stream each session will take 20-30 minutes long and for the control group, the psychology stream, it will take 50 minutes.

For the computer-based group children work in three phases : In phase 1 (three sessions), the learner will be working with introductory scenarios. Phase 2 (three sessions) consists of more complex situations, in which the learner will receive less feedback. The last phase is paper-based: the learner will have to identify a social situation him/herself, propose several possible solutions with justifications, and select one of them as the correct solution for the problem.

The control group work with a psychologist who will use a known method in psychology (role playing) to teach social problem-solving skills.

The study is voluntary, and the participants can leave whenever they wish, and withdraw any information gathered at any stage. Furthermore, participants will not receive any inducement for their participation in the study. Anonymity of the participants will be preserved in any publication about this research. The data collected in the study will only be accessible by the researchers involved in study and will be kept in a secure location. All collected data will be destroyed ten years after the completion of the PhD study. The research findings will be published in conferences and journals, which are accessible through the university libraries.

7 DOES THE PROJECT INVOLVE A QUESTIONNAIRE? **No**

If Yes, please attach a copy, if possible.

8 (a) DOES THE PROJECT INVOLVE A STRUCTURED INTERVIEW? **No**

If Yes, please list the topics to be covered and the questions to be used.

(b) DOES THE PROJECT INVOLVE AN UNSTRUCTURED INTERVIEW? **No**

If Yes, please list the range of topics likely to be discussed.

(c) IF THE PROJECT INVOLVES AN INTERVIEW OF EITHER TYPE, WILL IT BE RECORDED BY: AUDIO-TAPE **No**

OR VIDEO-TAPE? **No**

NOTE: This also covers focus groups.

(d) WILL THE PARTICIPANTS BE OFFERED THE OPPORTUNITY TO CHECK THE TRANSCRIPT OF THE INTERVIEW? **NA**

This also covers focus groups.

B. PARTICIPANTS

9 (a) WHO ARE THE PARTICIPANTS?

20 Children without ADHD and 40 children with ADHD. The ADHD children should be under medication. All participants are 8 to 12 years old.

(b) HOW ARE THEY TO BE RECRUITED?

If recruitment is by advertisement or letter or notice, please attach a copy.

The recruitment process is as below:

Dr.Najmi will contact his psychologists and psychiatrics colleagues who work with children and adolescents and tell them about the project. He will explain to them that he is the associated supervisor of a project, which is for a PhD student of the University of Canterbury in New Zealand. Then he will invite them to his office in order to give them *more detail and show the software and the setting to them. They will have the opportunity to work with the software themselves to make sure no hazards will be involved. After being clear about the procedure they will search through their patients, find children who are suitable for our study and contact them to see whether they are happy to participate or not. If yes, they will ask them to call Dr.Najmi and set a time to come to the clinic and get more information about the study. After that they can decide whether they would like to bring their children or not.*

ADHD children will be allocated to the computer-based or the control stream (led by psychologist) randomly.

(c) WILL ANY FORM OF INDUCEMENT BE OFFERED? **No**

If Yes, please give details and a brief justification.

(d) IF A SELECTION FROM A GROUP IS NECESSARY, HOW WILL IT BE MADE?

The ADHD children will be put into experimental or control group randomly.

(e) HOW MANY PARTICIPANTS (OF EACH CATEGORY, WHERE RELEVANT) DO YOU INTEND RECRUITING?

Sixty children aged 8 to 12 will be invited to participate in this study. Forty participants will be children with ADHD, and the remaining 20 will be children without ADHD.

We will have three streams where children will learn about social problem-solving method. In the first stream twenty ADHD children work with the computer tutor for 8 sessions. In the second stream twenty non-ADHD children also work with the computer tutor and finally in the third stream another twenty ADHD children work with a psychologist who will use a *known method in psychology (role playing) to teach social problem-solving skills.*

C. INFORMATION AND CONSENT

10. WHAT INFORMATION IS BEING GIVEN TO PROSPECTIVE PARTICIPANTS?

Please attach a copy of the Information Sheet (or sheets if there are different categories of participant or if responsible persons other than participants need to be informed).

If information is being supplied orally, please provide a full description of the information provided.

If information is to be provided via electronic means, please provide a copy of the webpage or link containing the information.

Separate information sheets and consent forms are required if there are different categories of participant or if consent is needed from responsible persons other than participants.

For children and young adults, please provide an information sheet and an assent form even if consent for their participation is sought from a parent/caregiver.

NOTE: Projects which involve only an anonymous questionnaire may not necessarily require a separate information sheet, provided that the rubric of the questionnaire includes your name and contact number as well as the other points contained in the model shown in the Guidelines. In general, however, the HEC recommends that participants be given an information sheet, which they may retain, unless there are good reasons against such a procedure.

11 HOW IS INFORMED CONSENT TO BE OBTAINED?

(a) The research is strictly <u>anonymous</u>, an information sheet is supplied and informed consent is implied by voluntary participation in filling out a questionnaire (include a copy of the rubric for the questionnaire as in Appendix C of the Guidelines) **No**

This means you do not know the identity of any of the participants and will not include any personal participant details.

Each participant will be assigned a code number. Names of individuals will not be used.

or (b) The research is not anonymous, but is <u>confidential</u> and informed consent will be obtained through a signed consent form (include a copy of the consent form and information sheet) **Yes**

This means that while you do/may know the identity of the participants, with respect to the data provided, you will not make their identity public.

Where confidentiality is promised, what will be done to ensure that the identities of participants cannot be known by unauthorized persons? (e.g. use of pseudonyms and disguising of identifying material).

Each participant will be assigned an id, and the data will be kept under the ids.

or (c) The research is <u>neither anonymous nor confidential</u> and informed consent will be obtained through a signed consent form (include a copy of the consent form and information sheet). **No**

or (d) Informed consent will be obtained by some other method – please specify and provide details. **No**

12 ARE THE PARTICIPANTS COMPETENT TO GIVE INFORMED CONSENT ON **No**

THEIR OWN BEHALF?

NOTE: Children and young adults under the age of 16 years (or 18 years if still at school) require parental/caregiver consent as do adults with disabilities that limit comprehension and consent. Such participants should be provided with a suitable information sheet and an assent form where practicable.

If No, please explain:

(a) Why they are not competent to give informed consent on their own behalf.

Because they are 8 to 12 year olds (under the age of 16)

(b) How consent will be obtained.

Consent will be obtained from their parents.

D RISK, DECEPTION, PRIVACY

13. WHERE WILL THE PROJECT BE CONDUCTED?

NOTE: It is recommended that interviews be conducted in public spaces and where possible, not in private homes. In the case of research involving children, young adults and participants with disabilities, an adult other than the researcher is required to be present.

The study will be conducted at the NasimBamdad Clinic where the associated supervisor works. He has allocated a separate room to the study. The computer and the locked drawer are in this room too.

14. FORESEEABLE RISKS TO THE PARTICIPANTS

If the answer to any of these questions is “Yes”, please indicate briefly the nature of the risk and what actions you could take, or support mechanisms you could rely on, if a participant should become injured, distressed or offended while taking part in this project.

Support should not be undertaken by researcher. At the very least a list of support services should be included in the information sheet and also participants made aware of the possibility in the information sheet.

(a) Is there any risk to physical well-being? **No**

If yes describe processes in place:

(b) Could participation involve mental stress or emotional distress? **Yes**

If yes describe processes in place:

The participants might be stressed in the first session, when they would not necessarily understand what our expectations are from them. Dr Najmi, who is a clinical psychologist, will be present and will monitor the participants, and intervene if necessary. Also parents are allowed to stay with their children inside the room if they like.

(c) Is there a possibility of giving moral or cultural offence? **No**

If Yes, describe processes in place and consultation/awareness undertaken:

The animated scenarios have been designed so that they are culturally appropriate. The associate supervisor has approved them.

15. IS DECEPTION INVOLVED AT ANY STAGE OF THE PROJECT? **No**

If Yes, please

(a) Explain how and why it is to be used and how the participants will be 'debriefed' following their participation in the project.

(b) Attach a copy of the debriefing sheet prepared for use by the researcher or for distribution to the participants after their participation in the project or after the completion of the project.

16. WILL INFORMATION ABOUT THE SUBJECTS BE OBTAINED **No**

FROM THIRD PARTIES?

This includes ‘snowball’ recruitment and also the accessing of potential participants via a third party.

In general third party contact information should not be given directly to the researcher – participants should contact the researcher and/or agree to be contacted.

We will not use any information collected about the participants by the clinic.

F DATA STORAGE AND FUTURE USE

17 HOW WILL THE DATA BE STORED?

(a) Provide details of Where will the data with identifying information be securely stored?

The data collected in the study will only be accessible by the researchers involved in study and will be kept in a locked drawer at ICTG lab at the University of Canterbury. All collected data will be destroyed ten years after the completion of the PhD study.

(b) Provide details of Where will the data with no identifying information be securely stored?

During conducting the study all information will be stored on the main researcher's computer (not shared), located in the clinic, which is password protected. The written information will be kept in a locked drawer there too. The researcher and the associate supervisor are the only people who are aware of the password and have access to the locked drawers. After finishing the study all information will be moved to the locked drawer in ICTG lab at the university of Canterbury where they will stay for ten years after completion of the study. Only the researcher and *the principal supervisor has access to the locked drawer in ICTG lab too.*

NOTE: All storage facilities should be locked and should be in rooms which can be locked.

(c) Who, apart from the researcher and their supervisor (where applicable) will have authorized access to the data?

Nobody

Note: Research Assistants and Transcribers need their own confidentiality forms and their participation needs to be made known to participants.

(d) What will be done to ensure that unauthorized persons do not have access to the data?

During conducting the study all information will be stored in the main researcher's computer (not shared), located in the clinic, which is password protected. The written information will be kept in a locked drawer there too. The researcher and the supervisor are the only people who are aware of the password and have access to the locked drawers. After finishing the study all information will be moved to the locked drawer in ICTG lab at the university of Canterbury where they will stay for 10 years after completion of the PhD study.

(e) What will happen to the raw data at the end of the project?

NOTE: up to MA level data is kept for 5 years and then destroyed; for above MA and staff research, it is normal practice to keep for 10 years and then destroyed. Participants need to be informed of and consent to what is decided.All collected data will be destroyed ten years after the completion of the PhD study.

18 What plans do you have for publication of the data?

NOTE: Master's thesis and PhDs are public documents via the UC library database Also, participants should be offered summary of results

The research findings will be published as the PhD thesis report that will be available via the UC library. We plan to publish papers in open *journals about the results of the study. The results will be aggregated and summarized so that individual participant data is not identifiable.*

19 ARE THERE PLANS FOR FUTURE USE OF THE DATA BEYOND THOSE ALREADY DESCRIBED? **Yes**

If Yes, please describe the future use.

This project will be continued in future. I may need to refer to these data in future researches.

NOTE: It may be the case that such future use should properly involve the production at an appropriate later date of additional information sheets and/or consent forms prior to such use. In that case, copies of those additional documents should be sent to the Human Ethics Committee, along with a covering letter referring to the present project, for HEC approval.

Appendix C: The Consent Form for Participants

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Department of Computer Science and Software Engineering

Telephone: +98 913 1860614 (Iran) +64 278676488 (New Zealand)

Email: atefeh.ahmadi@pg.canterbury.ac.nz

Date: 1st March 2014

Consent Form for Participants

Mrs. Atefeh Ahmadi has explained her project to me and gave me enough time to ask as many questions as I liked.

I know what is going to happen in all eight sessions.

I have already seen the place where I will attend the sessions.

I understand that my parents can stay with me inside the room or outside in the waiting area during the sessions.

I know I can stop coming to the sessions whenever I wish no matter how many sessions I have already attended.

I understand any information about me will be kept secretly by Atefeh and her supervisors.

I understand that in case of any problems, like feeling stressed, I can inform Atefeh and she will attend to the problem immediately.

If I have any complaints, I can tell Atefeh, who will be present at all the times during the sessions. Also I can ask my parents to inform her supervisors or the University of Canterbury through the emails they have.

I agree to participate in this project.

Name:…………………………….

Signature: ……………… Date:……………..

Please return this form to the clinic's help desk

Appendix D: Problems Defined by Children in Phase 3

ADHD Children's Problems:

1- When my father was watching football match on TV, I wanted to watch my favourite TV series.

2- I had conflict with my mother when I wanted to choose what to wear.

3- I wanted to make a snowman but my mother said: "it is cold outside".

4- I wanted to go for a picnic with my classmates but my mother said: "it is cold outside".

5- I got a headache when I was in my friend's party.

6- I just bought a new eraser but I lost it at the school today. I have no idea how to explain it to my mother!

7- I lost the door keys when I was playing with snow today.

8- Today in the morning I just realized that I forgot to study Farsi.

9- I had an argument with my sister in order to play a game on the computer.

10- When I was going home the engine of school's bus stopped working and I was thinking about my mother who might get worried.

11- My cousin does not let me to use his computer.

12- I am afraid of the time that my teacher wants me to answer a question.

13- My leg got injured when I was playing in the school yard.

14- One of the students in our school is making fun of me.

15- I had a conflict with my friend in the school bus.

16- Sometimes I wake up at midnight and will not be able to go back to sleep again.

17- When the guests left, my room was messy.

18- I lost my book today and my name was not written on the book. I have no idea how to find it again.

19- Yesterday I fell of the swing and was not sure what to do.

20- My friend does not let me to be in the playing group.

21- I think Mrs Ahmadi does not like me anymore.

22- I do not learn mathematics.

23- Every night I have an argument with my mom regarding my time of sleeping. I do not want to go to bed early.

24- I wish to have an Xbox but my mother says it is expensive.

25- I need to print something but we do not have a printer at home

26- My mother promised me to bake a cake for me but now she says we have no milk at home and she cannot bake the cake.

27- The ink of my pen finished during the math exam.

28- I arrived late to school today.

29- My mark in math exam was not satisfactory enough.

30- My teacher asked me to type an essay but we do not have computer at home.

31- My friend lend his fish to me but yesterday I found the fish dead.

32- My new sport pant got ripped in the school and I'm afraid of the moment that my mother realizes it.

33- I wanted to build a car but I had only three wheels.

34- My student card fell into a dirty river.

35- A rude boy in the bus wanted to take my seat.

36- I need to buy something but the money that I have already ran out of my pocket money.

37- My friend's toy fell from my hands and broke

38- My mother wants my room to be always tidy but I prefer a messy room

39- I do not like to take a bath or shower. What should I do then?

40- I have given a forbidden food to my brother and I have no idea what to do!

NOADHD Children's Problems:

1- I don't like the clothes that my mother buys for me.

2- My friend keeps distracting me in the class and won't let me to concentrate.

3- My friend told me that she did not like the gift I gave her and I got upset.

4- Drinking milk is compulsory in the school and I hate milk.

5- I can't make friends at school.

6- I had a conflict with my brother.

7- My mother asked me to take the rubbish out and I forgot to do that.

8- I couldn't finish my homework last night.

9- Most of the days I'm late at school.

10- I want a cell phone but my mother says it is too early and I need to wait more.

11- My parents always have conflict at home and I do not like it.

12- My friend borrowed my book and never returned it.

13- Yesterday my teacher borrowed my favourite pen and I'm ashamed of asking her to return it to me.

14- We have to go to my grandmother's place every weekend and I do not like it there.

15-Yesterday my ball went to the neighbour's place when I was playing football.

16- My brother destroyed the puzzle that I drew hardly.

17- I lost the "Building Blocks" match in school and my classmates made fun of me.

18- I wore my mother's shoes to play but the heels broke.

19- In art class the colour splashed to my classmate's eyes.

20- My mother did not buy me the toy that I chose in the store.

21- I could not open the can of cola and we did not have can opener at home.

22- One of group mates did not let us to do anything and wanted to do everything by himself.

23- The topic for essay writing was difficult and I could not write anything.

24- I want to put lipstick on but my mom doesn't let me.

25- My father deleted my favourite game from the computer.

26- I forgot to take my homework note book to school.

27-The laptop charger got lost and I wanted to use the laptop.

28- My friend accused me that I opened his school bag.

29- I do not like my little sister.

30- The only cardboard that we had got ripped at school.

31- I did not well in my exam and my teacher said my mark out loud and I got upset.

32- One of students at school beats me.

33- The ball got flat at school when we were playing football.

34- When I was in the store I broke a bowl by accident and everyone looked at me.

35- My friend came to my room and made my room messy and my mother got angry.

36- I got really hungry when I was in my friend’s place but I did not like their food.

37- My cousin wanted to take my favourite toy with him.

38- I always have conflict with my brother.

39- I do not like the place that I’m sitting in the class.

40- My teacher wanted to talk to my mother and I was afraid.

Appendix E: Publications

1) Ahmadi Olounabadi, A., Mitrovic, A., 2012, Towards an ITS for Improving Social Problem-Solving Skills of ADHD Children, *ITS2012 Conference,* pp. 603-605, Crete, Greece.

2) Ahmadi Olounabadi, A., Mitrovic, A., 2012, An Intelligent Tutoring System for ADHD Children to Teach Social Problem-Solving Skills, *NZCSRSC2012 Conference,* Dunedin, New Zealand

Towards an ITS for Improving Social Problem Solving Skills of ADHD Children

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Abstract. The major problem of ADHD (Attention Deficit Hyperactivity Disorder) is the lack of social skill and personal relationships, which leads to peer rejection and society isolation. As the result, they often develop depression and other mental disorders. Effective educational software for ADHD children is of great societal importance as evidenced by the high proportion of this disability in the population (8% to 10% [5]). The main aim of this research is to develop an ITS for ADHD children to teach them social problem-solving skills. The proposed system will enable children to solve everyday problems, which leads to a better life in which there is no peer rejection as well as a strong foundation for their adulthood.

Keywords: ADHD Children, Social Skills, Problem-Solving Skills, Computer-Based Training, Intelligent Tutoring Systems

Introduction

ADHD is a developmental disorder composed of different difficulties with unknown aetiology [1]. People with ADHD simply cannot control their behaviour. Inattention, hyperactivity and impulsivity are the three symptoms of ADHD [2-3]. ADHD people also have major problems in their relationships with other people around them which might be taken into their adulthood in lack of proper treatment [3]. This disorder has been diagnosed as the most common childhood behaviour disorder affecting 8% to 10% of children [4-5]. Both assessment and therapy are needed for this disorder best before the age of seven, as untreated ADHD has significant impact on the child, their immediate family and the whole society [5]. Moreover the probability of performing risky actions like dangerous driving [5-6] or crime commitment [7] is high amongst ADHD adults. Untreated ADHD children have problems in higher education. Their problems in personal relationships, social skills, time management and self-organization lead to society isolation which may lead to depression or other mental problems [8]. So having a way of helping ADHD children to control their disorder, we equipped them with a well-organized foundation for their future.

Method

There are three main elements for social skills: social intake, internal processing and social output. Traditional problem-solving strategies do not work well for ADHD children. The reason is they do not practice the learnt lessons in the real life, so they have short term effects. On the other hand, due to mental disorders, ADHD children learn very hard and forget about lesson learnt easily. Also, new approaches have to be tailored for them to be applicable. Centre of social success in Dallas introduced a method for problem solving called POPS [9]. It is an abbreviation for: Problem, Options, Pick, and Solve or Start again. Applying POPS, children are asked to define a problem. Then they are given some options. They are asked to pick an option and try it. If the chosen option is able to choose the problem, the process ends, otherwise they have to start again. In Social Autopsy, children are asked to give their solution options themselves even if they have an adult's support. ADHD children normally cannot give any justification for their actions, especially the ones who have hyperactivity or impulsivity symptoms. Giving their own solution options is a hard task for them especially when they have to be flexible enough to change it without any help. In my project, I am going to adopt an integration of POPS and Social Autopsy and develop a software system according to this new approach specific to ADHD children.

The first step in designing system is to find out what social skills 8 to 12 years old children should know. The social context is another important factor that has to be considered. After choosing the skill they like to practice, the child will be asked to define the problem context. The problem context is any different places where the child could be during the day and therefore is another important factor that has to be considered. The system will then select a problem with an animated scenario to help children to imagine themselves in the real situation. The child's progress will be tracked and recorded with each session to monitor improvements or difficulties with each task. It also helps in choosing the next appropriate problem for the child. Going through different phases of the system depends on successive scores of the previous phases. The learning process is multi-level and is divided to three phases with increasing level of difficulty in each phase.

Phase 1: System poses a problem to the child. When s/he becomes familiar enough with the question, system will give her/him a list of solution options. The child chooses one option. Then system will ask for a justification for her/his choice with a supporting list of justifications. The system provides feedback for each step in this phase. An example: Imagine the child has selected the "Requesting Help" skill in the context of school yard. A problem could be: Your mom was supposed to come and collect you after school, but she is late and you are worried. Who is the best person to get help from?" This scenario would be an animated and colorful view and the child can see a figure as a symbol of him/her in that environment. The child has to click on the right object which in this case is the school's principal. If a wrong object was clicked, the system asks for a justification which in this phase is given as a pop down menu.

Phase 2: Once the child has got enough practice and success in stage one, they enter phase 2. In this phase again problems are given to the child, but instead of making options available, s/he has to come up with options themselves. They also have to give justification for each choice.

Phase 3: This phase is an advanced mode which will be open-ended, so that children have to enter not only the solution options, but also their own problem to the system and go through the social problem solving skills independently like the real life. The system will not provide a lot of feedback in this phase.

Pre-test and post-test are being done by psychologists who measure certain factors using pre-designed standard tests. Additional related factors such as response time, interaction time or correctness rate will be logged so that children's behaviour can be studied while they are working with the system. Furthermore, children will work with two versions of the system; a version without feedback, and an adaptive version with feedback. This is to evaluate effectiveness of the training in particular.

The software system should be attractive enough to absorb ADHD child's attention. The object of the displayed scenario will be moved to different places each time, so if the child have a better performance next time when s/he works with the system we can make sure s/he has not memorize the object's place. Therefore we evaluate the child's improvement with more confidence. The proposed system will be developed specifically for ADHD children. Using this system they can become good social problem solvers.

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Attention Deficit Disorder Association (ADDA): https://www.adda-sr.org/reading/Articles/Istreempowering.htm. Empowering ADHD Children to Become Better Social Problem Solvers.

An Intelligent Tutoring System for *ADHD* Children To Teach Social Problem Solving Skills

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ABSTRACT

ADHD (Attention Deficit Hyperactivity Disorder) children's major problems in social skills and personal relationships lead to peer rejection and society isolation. As a result, they may add depression and other mental disorders to their current deficit state. Having 8% to 10% ADHD children, the need to develop personalized educational softwares for them is inavoidable. The main aim of this research is to develop a software training system for ADHD children to teach them social problem-solving skills. The proposed software is going to make them into independent social-problem solvers. Therefore they will be able to solve everyday problems which lead to a better life in which there is no peer rejection as well as a strong foundation for their adulthood.

General Terms

ADHD Children, Social Skills, Problem-Solving Skills, Computer-Based Training, Intelligent Tutoring Systems

1. INTRODUCTION

A special kind of mental state which causes restlessness and problems with attention was first introduced by Sir Alexander Crichton in 1798 (Palmer et al., 2001). Although he did not call that state ADHD (Attention Deficit Hyperactivity Disorder), its features are exactly what we know as ADHD now. He wrote a full chapter about this disorder in his book "An Inquiry into the Nature and Origin of Mental Derangement" (Palmer et al., 2001). After Crichton's work researchers started to study this mental state on people of different ages but a remarkable rise of interest in children's mental health can be noticed since 1994 (Wilson, 2004). ADHD is a developmental disorder composed of different difficulties with unknown etiology (Parsons et al., 2007). People with ADHD simply cannot control their behaviour. Inattention, hyperactivity and impulsivity are the three symptoms of ADHD (Excoffier, 2006; Cho et al., 2002). With a more detailed look at ADHD behaviours, some researchers like (Parsons et al., 2007) consider extra symptoms like distractibility and cognitive flexibility. Cognitive flexibility is one of the human abilities that help a person to change his/her behaviour according to the situation. ADHD people also have major problems in their relationships with other people around them which might be taken into their adulthood in lack of proper treatment (Cho et al., 2002). This disorder has been diagnosed as the most common childhood behaviour disorder affecting 8% to 10% of children which they carry into adolescence in approximately 80% of cases (Slate et al., 1998; Anton et al., 2009). Both assessment and therapy are needed for this disorder best before the age of seven, as untreated ADHD has significant impact on the child, their immediate family and the whole society (Anton et al., 2009). They would take their problem into their adulthood. Moreover the risk of performing risky actions like dangerous driving (Thompson et al., 2007; Anton et al., 2009) or crime commitment (Fletcher et al., 2000) is high amongst ADHD adults. According to the U.S. Centres for Disease Control and Prevention more than 5 million children in the United States have been diagnosed with ADHD until 17 October 2011 (MedlinePlus, 2011). Also, as they are not able to focus on a task they cannot finish it, so they change job quite often (Thompson et al., 2007). Untreated ADHD children have problems in higher education. In addition to that, their problem in personal relationships, social skills, time management and self-organization leads to society isolation which may lead to depression or other mental problems (Harpin, 2005). So having a way of helping this huge amount of ADHD children to control their disorder, we equipped them with a well-organized foundation for their future.

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2. BACKGROUND

There are three main symptoms known for ADHD: inattention, hyperactivity and impulsivity, each one with specific behaviours related to it. Inattentive children are not able to focus on a task and become easily distracted. So, classroom is the biggest challenge for them as there are a lot of distractions in the classroom. They also seem not to listen when they are spoken to. On the other hand hyperactive children are full of energy so that they cannot stop moving. Also, they talk a lot with a loud voice. Sitting at dinner table or at classroom or waiting for their turn in games or waiting in a queue is troublesome for them. They often misplace things and are late for their appointments or classes.

Normally in doing almost anything we think and then take action, so that we would be safe in risky situations because of considering the consequences of our actions. Unfortunately impulsive children just do not think before doing something. Instead they act upon the first thing that comes to their mind, so they are very impatient and sometimes they make inappropriate comments. Also they show their emotions without any control and if they are asked for a reason of their actions, they just do not know.

To control the symptoms of ADHD, drugs have been used for decades. Medications that seem to be the most effective are a kind of drugs called stimulants. In addition to that a group of researchers started to find new ways of treatments using vitamins and minerals. In an open-ended trail, Rucklidge et al. (2010) reported a significant improvement in hyperactivity and impulsivity deficits after using vitamins and minerals for ADHD children for 8 weeks. When a child's schoolwork or behaviour improves soon after using the drugs, his/her parents and teachers think medication is all s/he needs. Although these treatments are successful, there are some problems with them: 1) Inconsistent implementation of the treatment may cause poor results or even make the symptoms worse (Slate et al., 1998). 2) These treatments are not sufficient to transform a problematic child to a normal one especially at academic and social functioning (Cho et al., 2002). 3) Medical effects are short-term and limited to the period of intervention as discontinuing of medical treatments cause rapid return of symptoms (Slate et al., 1998; Anton et al., 2009; Cho et al., 2002). 4) Children do not respond to the medical treatment equally (Anton et al., 2009). 5) There are social and psychological consequences for children themselves in their future life when they come to know that their behaviour has been controlled by drugs (Douglas et al., 1976). 6) They are mostly effective in motor function but not working much for treating information processing, emotional problems, high inattentive conditions and so on (Kotwal et al., 1996). Medications help ADHD children to pay more attention to be able to finish their homework or learn a subject. They do not improve academic skills just help the child use the skills that he or she already has. About 80% of children who need ADHD medication still need it as teenagers and over 50% needs these drugs as adults.

Medical treatment has been popular until 1976, but since then research focused more on cognitive, behavioural approaches and self-control. Preferred non-medical treatment for ADHD is behaviour therapy and operant condition techniques (Douglas et al., 1976; Kotwal et al., 1996). Several different non-medical approaches has been applied to treat ADHD (Kotwal et al., 1996), for instance: Self-instructional training, Green therapy (Taking child to nature), Music therapy, Sensory therapy (Massage), Working memory therapy, Art therapy,Role playing, Cognitive modelling, Self-monitoring, Self-reinforcement, Cognitive and interpersonal problem solving, Behavioural Therapy, Biofeedback training (Useful in controlling hyperactivity) (Kotwal et al., 1996). Although some of these methods caused a huge improvement on ADHD symptoms, Kotwal et al. (1996) believe they have moderate or short-term effects in cognitive and behavioural functionalities. Klingberg (2010) believes that children with ADHD sometimes have problems with working memory (WM). The result of this research shows that one can improve performance of working memory tasks by training. This training also has a significant effect on motor activity in children with ADHD (Klingberg et al., 2002). Anton et al. (2009) believe that although both medication and behavioural approaches are effective, limitations exist. Therefore additional strategies and approaches are needed. By the way, National Resource Centre on ADHD believes that Behavioural Modification is the only non-medical treatment for ADHD with a large scientific evidence base. Behaviour Modification intervention consists of different steps which are done for the Child's himself/herself, his/her parents and teachers as well. First step: Evaluation Pre-Test A comprehensive evaluation is being done by assessing all three parties including the child, his/her parents and teachers. This is been done by a professional using appropriate psychological tests. Tests are both behavioural and academic and child's state is considered at home, at school and in social settings. It should be kept in mind that most of the information at this stage is received from teachers and parents. Second step: Treatment Tailoring Target behaviours are set at this stage. These behaviours are those which need to be changed in ADHD children. It can be negative behaviours that need to be stopped or positive ones that need to be gained. The most problematic behaviour is lack of social skills especially taking turns, sharing, not being bossy, problem solving and in total interaction with peers. An appropriate treatment is being tailored by the professional according to the evaluation result, nominated target behaviours, child's age and the socioeconomic conditions of the family which affects how soon they get used to the exercises. This treatment includes different practices that have to be done in public places by all three mentioned parties. Third Step: Result Recording After doing each practice, information should be recorded in specific forms provided by the professional. Forth step: Evaluation Post-Test Again yet another set of tests are done on all three parties to check the child's progress and then treatments repeats from second step again as long as it is needed.

After a lot of research, National Resource Centre on ADHD believes that although some families prefer their child's treatment without using any medication, behavioural therapy is not effective on its own without medication (Slate, 1998). So, medical, educational and behavioural therapy is needed to treat ADHD. This combinational treatment is called "Multimodal Therapy". National Institute of Mental Health, conducted a research on multi treatment study for children with ADHD. Four different treatment forms have been compared including: behavioural treatment (BT), Medication Management (MM), Combined Behavioural treatment and Medication Management (COM) and a community treatment by own choice as a comparison control group (CC) (Douglas et al., 1976). This method has been considered as the most effective one, and means that the therapist works on the cognitive and behavioural level of the child including both parent training and child training (Anton et al., 2009). This kind of therapy is called "Cognitive Behavioural Therapy" (CBT) which is encompasses of three techniques: Reinforcement techniques, Techniques for eliminating maladaptive behaviour, Cognitive restructuring technique (Anton et al., 2009). Nowadays instead of external operant techniques, self-reinforcement and self-control techniques are considered so that ADHD children would be able to help themselves without much need from outside agents (Douglas et al., 1976)

Social skills have been defined by Spence (2003) as the ability of performing those behaviours that are critical in enabling a person to achieve social competence. However, she has defined social competence as the ability to obtain successful outcomes from interactions with others (Spence, 2003). Children normally learn social skills by watching their parents, copying the schoolmates' behaviour or learning from feedback. ADHD children simply miss these lessons as they have learning problems, emotional problems, conduct disorders and general psychiatric problems (Jacobs et al., 2010; Spence, 2003). As a result they cannot realize right and wrong issues easily and repeat ineffective behaviours (Jacobs et al., 2010). They are bossy, disruptive and easily frustrated in group play and Therefore a great number of them encounter difficulties in their everyday relationships (Spence, 2003). According to National Resource Centre on ADHD 50% to 60% of them cannot make healthy peer relationships. The main drawback of not learning social skills in ADHD children is peer rejection which cause low self-esteem, depression and anxiety. Also, they take any unresolved problem to their adulthood. Moreover, by learning social skills, they can improve their peer relation, academic progress, taking responsibilities, self-esteem and problem solving (Jacobs et al., 2010). Knowing how to solve a problem in social contexts is equally important as in educational contexts. When a child has some cognitive deficits, solving everyday social problems like having an argument with a friend or not been invited for a party can be as difficult as solving a difficult math problem for him/her. That is because people with cognitive deficit like ADHD people cannot apply methodical problem-solving skills naturally. Therefore, their actions are mainly on trial and error and they repeat the same error quite often. A need to teach problem-solving strategies to them from early ages can be observed here. Different approaches that have been designed and applied to teach children how to solve problem, can be divided in two main categories: traditional approaches and modern approaches. The main difference between these two approaches is traditional approaches do not practice learnt skills in real life, while modern ones make sure that children can apply their skills in real life immediately after learning. Traditional approaches are not effective enough with short-term effect. Some examples of this approach are Role playing, Demonstration, Videotaping and Lecturing. There are also new approaches are an authentic real-life laboratory. POPS and Social Autopsy are well known new problem-solving methods. Centre of social success in Dollas introduced a method for problem solving called POPS (Istre, 2011). It is an abbreviation for: Problem, Options, Pick, and Solve or Start again. Applying POPS, children are asked to define a problem. Then they are given some options to choose from. After that, they are asked to pick an option and try it. If the chosen option is able to choose the problem, the process ends, otherwise they have to start again and choose another option. According to Oxford dictionary the word Autopsy means: "A post-mortem examination to discover the cause of death or the extent of disease". However, Social Autopsy is "Examination and analysis of a social error to determine the cause of the error, the amount of damage that occurred and to learn about the causal factors in order to prevent reoccurrence in future". Social Autopsy enables the children to realize not only their errors, but also the cause and consequences of their behaviours on people around them and on the whole society as well. Social Autopsy is done in 5 steps: -Asking the child to explain what happened -Asking the child to identify the mistake made -Assisting the child in the actual social error determination - Building a similar scenario - Giving the child a social homework.

3. RELATED WORK

Researchers have been trying to develop computer-assisted applications for ADHD people and also by everybody who is dealing with them from psychologists to parents and teachers. Different studies (Kotwal et al., 1998; Slateet al., 1998) have proved the effectiveness of computerized training for ADHD Children. Computer-based applications can be placed into different categories.

One of these categories are Diagnostic Computer Tests which have been used by psychologists and researchers to diagnose people with ADHD more efficiently. Also, computers can be used as a tool to score tests, generate an interpretive profile based on normative data and track patient's improvement during the treatment period (Rosen, 1995). Using computerised tests a huge amount of time would be saved both for psychologists and patients (Rosen, 1995).

Another group of computer-bsed applications are Educational and Training Applications. So far, researchers have put a significant effort into developing computer applications that are able to train people with cognitive problems to overcome their problems. Although even by using those applications they cannot live completely free of their problem, they can control it to a degree. Some applications that are been used by ADHD people and the psychologists who work with them are introduced here:

Virtual Classrooms: Having the ability of delivering rich environments, predicting and improving daily life, VR has been increasingly used in a number of psychotherapy and rehabilitation contexts. VR has made sophisticated interactions, behavioural tracking and performance recording possible (Anton et al., 2009).Due to four factors VR can help patients hold their attention for longer. These factors are being immersive, interactive, imaginable, and interesting (Cho et al., 2002).The most common use of VR in study, assessment and rehabilitation of ADHD is virtual classrooms.In another research conducted by Cho et al. (2002) a classroom-based virtual environment was developed. The idea behind this research is that they believe children spend much time in the classroom, so they should pay attention to classroom tasks (Cho et al., 2002).After taking their system into practice, Cho and his group realized that the virtual classroom itself is very attractive to the children, but not the training tasks by which they were able to use the system more efficiently. (Cho et al., 2002).

THINKable IBM: This software tool has been designed by IBM and can be used by people with cognitive disability. It provides a structured environment in which thinking skills needed in daily life can be practiced. Among different skills THINKable works on four main areas including: visual attention, visual discrimination, visual memory and visual sequential memory. Challenging and productive practice sessions can be planned and implemented easily (Abledata, 2003). Software, hardware and information are combined in Thinkable to make a versatile tool to be used in the field of cognitive rehabilitation (Kotwal et al., 1996; Butt et al., 1998). THINKable has different tasks that can be customized according to the patient's treatment plan. In addition to automatic data collection and reporting system, THINKable is able to provide some set of treatments plans, by which clients can take advantage of some semi-automated therapy sessions too (Abledata, 2003; Riccio, 2004). Feedback is given all along the treatment process as well. In an experiment research conducted by Butti et al.(1998), THINKable was applied for the treatment of 12 mentally impaired elderly patients. As a result not only their neuropsychological performance improved significantly, but also a great improvement was observed in those abilities which had not been directly trained. This study reported a 10% improvement in overall Wechsler memory after cognitive training by THINKable. Also, the patients experienced improved self-esteem and significant improvement in logical memory and visual reproduction during and after treatment.

Captain's Log: Captain's log is cognitive training software designed by Sanford and Browne in 1988. It is a complete computerized mental gym. It consists of several modules which provide 50 multilevel programs in more than 2000 hours of game-like brain training progressive challenges(Slate et al.,1998). Kotwal (1998) describes Captain's log as a computerized system containing a wide range of cognitive exercises designed to help develop attention, concentration, memory, eye-hand coordination, basic numeric concepts and problem-solving reasoning skills. It consists of different exercises from easy to more challenging cognitive training tasks, suitable for children as young as 6 through adults(Kotwal et al., 1996). In a study conducted by Kotwal et al. (1995), Captain's log was used in a case study on ADHD participants and as a result a significant change in on-task behaviours and a reduction of disruptive behaviours were obtained (Slate et al., 1998;Kotwal et al., 1996). After getting such positive results, Kotwal et al. (1998), claimed that their study provides some helpful evidence for the usefulness of computerized cognitive training for ADHD children. On the other hand, in another study that supports Kotwal's conducted by Slate et al. (1998), an evolutional training on four severely emotionally disturbed ADHD children was performed. The main aim of this study was to assess the influence of Captain's log on behavioural and performance capabilities of ADHD children. The result showednewlydeveloped skills stay with ADHD children after stopping the treatment which is a big achievement especially for dually diagnosed childrenwith two different disorders simultaneously. Moreover, according to this study, with multilevel cognitive training games Captain's log helped ADHD children to enhance non-equally developed skills. This software is also rewarding as children in (Slate et al.,1998) desired to continue training after the research was completed.

FaceSay: FaceSay is social skill training software with three different games which aims to teach some specific social skills to children with mental disorders mainly with Autism. The target social skills include recognizing eye gaze directions, emotions and facial expressions (Hopkins et al., 2011). The demo version is available free of charge on the Internet at this address: http://www.facesay.com/demo.html . The games are multi-level so that there are both easy and difficult games in this package. The child's name is been asked by a baby when a user starts FaceSay which been used by the system when feedback is given to the user along the way by simply calling the user's name. This software has the advantage of providing a computer-based environment in which an avatar interact with children and assist them to improve their social skill abilities. The avatars are animated photos of real persons that act upon a pre-programmed knowledge base. The main idea of using an avatar is to provide a more realistic environment by which children can put their learnt social skills into practice more easily (Hopkins et al., 2011).

Lumosity: At Lumo lab situated in San Francisco, US, there is a strong belief in brain improvement. They have developed an online tool for cognitive enhancement called Lumosity. It offers brain training exercises for people with different level of cognitive skills. People can get mentally fit working with different well-designed exercises with Lumosity (Hardy, 2009). Lumosity gives a customised brain fitness plan to the user. The process starts by asking the user which core brain areas s/he is aiming to develop: memory, attention, speed, flexibility or problem solving and then according to his/her choice suitable game is made available to him/her to play. Researchers in Lumo lab claim that according to different clinical trials Lumosity has been able to improve some brain functionalities like working memory, visual attention, fluid intelligence, and executive function. So, Lumosity has shown a real-world cognitive benefit for individuals of all ages. Lumo lab are proud of their product as it has been applied in different scientific and research area and projects like European Space Agency's Mars500 which is a stimulated trip to Mars (Hardy, 2009).

4. METHOD

There are three main elements for social skills: social intake, internal processing and social output. Traditional problem-solving strategies do not work well for ADHD children. The reason is they do not practice the learnt lessons in the real life, so they have short term effects. On the other hand, due to mental disorders, ADHD children learn very hard and forget about lesson learnt easily. Also, new approaches have to be tailored for them to be applicable. In Social Autopsy, children are asked to give their solution options themselves even if they have an adult's support. ADHD children normally cannot give any justification for their actions, especially the ones who have hyperactivity or impulsivity symptoms. Giving their own solution options is a hard task for them especially when they have to be flexible enough to change it without any help. In my project, I am going to adopt an integration of POPS and Social Autopsy and develop a software system according to this new approach specific to ADHD children. The software system will be developed based on integration of POPS and Social Autopsy.

Figure 1: First Window

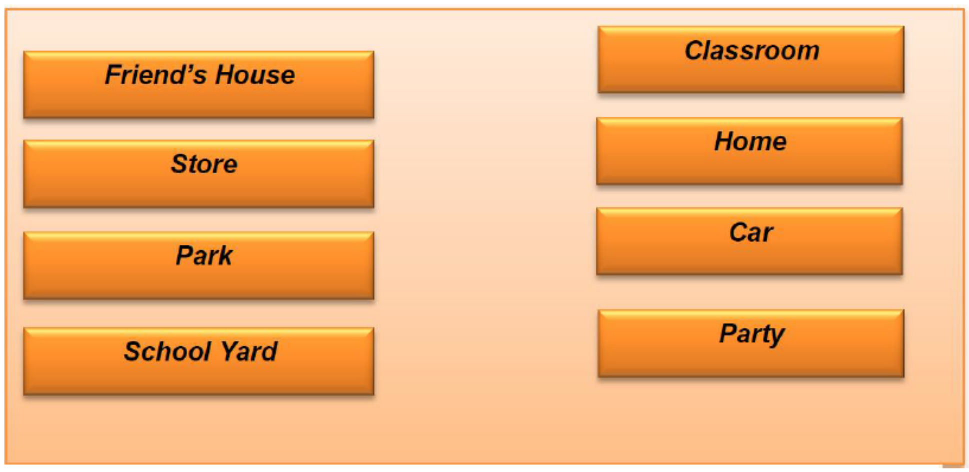

Figure 2: Second Window

The new strategy will include both strategies' advantages. Meanwhile, children teach to solve their problems independently without a need for having a supportive adult by them in Social Autopsy. The proposed system will be developed specifically for ADHD children. Using this system they can become good social problem solvers. Therefore, they will experience less peer rejection, and build up their self-esteem and make a strong foundation for their adulthood

4.1 Software Design

The first step in designing system is to find out what social skills 8 to 12 years old children should know. For example in (Zande, 2011) some social skills specific to this age range has been listed as: Requesting help, offering assistance, saying 'NO', Requesting information, Asking to join in, Offering invitation, Cooperating and Following directions. On the other hand, children could be in different places during the day, so the problem context is another important factor that has to be considered. So, in my system a problem will be shown after passing through two windows.After choosing the Main problem(Figure 1), the child will be asked to define the problem context. It can be done simply using another window(Figure 2).Having these two windows helps the child to work on the context that s/he has more difficulties with it. A problem related to what has been chosen in previous windows is shown to the child. The problem will be an animated scenario to help children to imagine themselves in the real similar situation. Progress on the software system is tracked and recorded with each session to monitor improvements or difficulties with each task. It also helps in choosing the nest appropriate problem for the child. Going through different phases of the system depends on successive scores of the

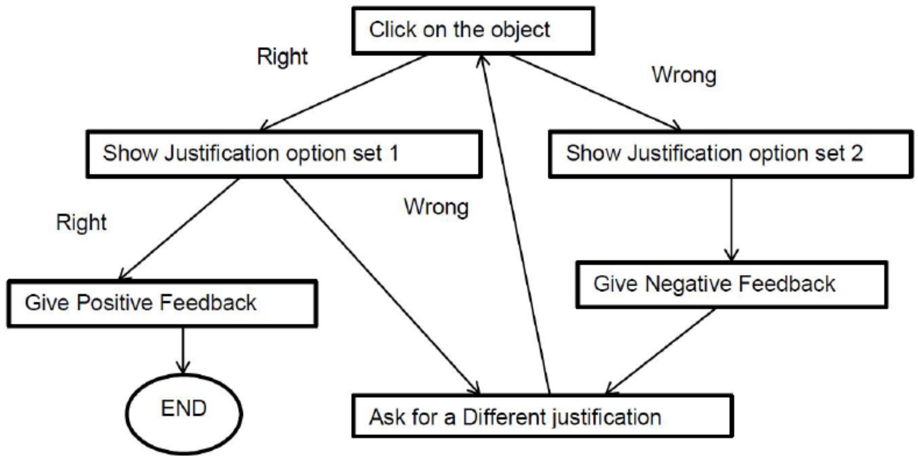

Figure 3: Process Flowchart

previous phases. The learning process is multi-level and is divided to three phases with increasing level of difficulty in each phase.

Phase 1: System poses a problem to the child. When s/he becomes familiar enough with the question, system will give her/him a list of solution options. The child chooses one option. Then system will ask for a justification for her/his choice with a supporting list of justifications. The system provides feedback for each step in this phase. An example: Imagine the child has click on the "Requesting Help" button in the first window and on the "School Yard" button on the second window. A problem could be: Your mom was supposed to come and collect you after school, but she is late and you are worried. Who is the best person to get help from?" This scenario would be an animated and colourful view and the child can see a figure as a symbol of him/her in that environment (Figure 4).The child has to click on the right object which in this case is the school's principal. If a wrong object was clicked, the system asks for a justification which in this phase is given as a pop down menu. The process is been shown as a flowchart in Figure 3. These windows have been put here as an over-simplified design. It should be very attractive and based on ideas from psychology researchers to make it appropriate for ADHD children in the real software system.

Phase 2: Once the child has got enough practice and success in stage one, they enter phase 2. In this phase again problems are given to the child, but instead of making options available, s/he has to come up with options themselves. They also have to give justification for each choice.

Phase 3: This phase is an advanced mode which will be open-ended, so that children have to enter not only the solution options, but also their own problem to the system and go through the social problem solving skills independently like the real life. The system will not provide a lot of feedback in this phase.

The software system should be attractive enough to absorb ADHD child's attention.The object of the displayed scenario will be moved to different places each time, so if the child have a better performance next time when s/he works with the system we can make sure s/he has not memorize the object's place. Therefore we evaluate the child's improvement with more confidence.

5. CONCLUSION

So far, there have been a huge number of studies conducted to help ADHD children towards a better life. Some researchers have worked on cognitive-training approaches and tried to improve those skills that ADHD children lack like eye gaze, emotion recognition, working memory improvement and so on. Although there seems a lot of efforts towards covering all the social skills, it seems there has not been any work done on developing a specific software system to improve ADHD's everyday social problem-solving skills. The proposed software is aiming to fill this gap by developing an ITS for ADHD children age 8 to 12, to teach them how to solve their everyday problems independently. The software system will be developed based on integration of POPS and Social Autopsy. The new strategy will include both strategies' advantages. Meanwhile, children teach to solve their problems independently without a need for having a supportive adult by them in Social Autopsy.Using this system, they can become better social-problem solvers. Therefore, they will experience less peer rejection, and build up their self-esteem and make a stronger foundation for their adulthood. The proposed software is supposed to reduce conflicts between ADHD children with the people around them especially parents and teachers. Also, it aims to help them control their symptoms and learn new skills easier.

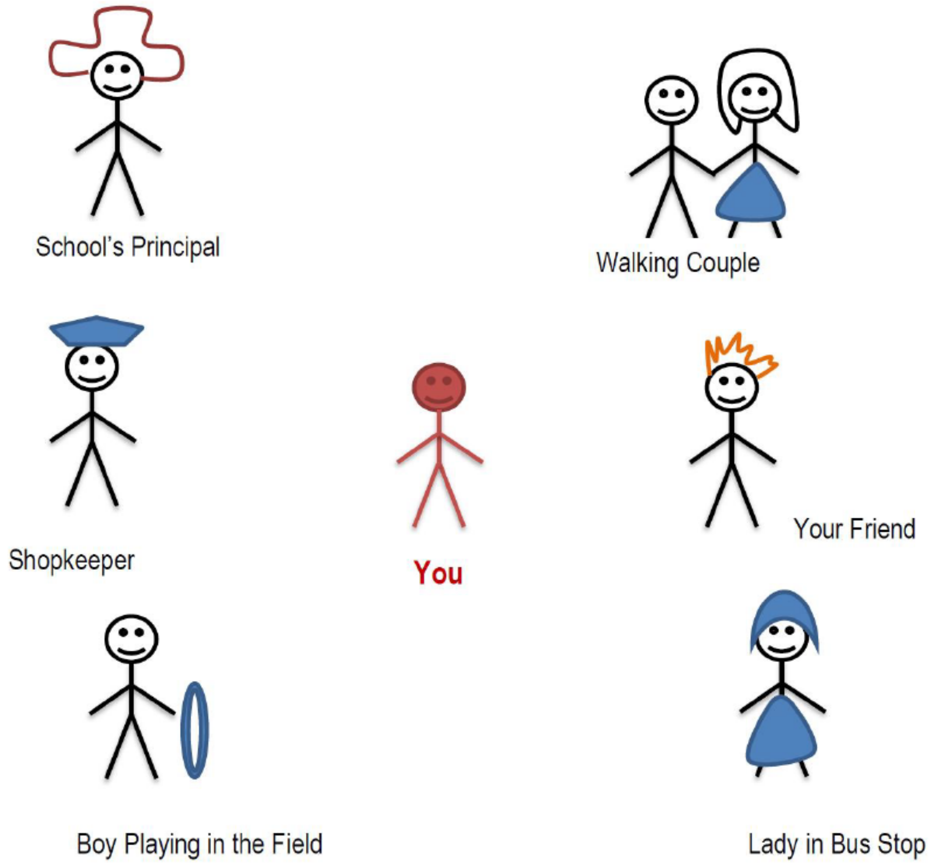

Figure 4: A Sample Scenario

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